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THE TAYLOR SYSTEM IN FRANKLIN MANAGEMENT

APPLICATION AND RESULTS

BY

MAJOR GEORGE D. BABCOCK

PRODUCTION MANAGER, H. H. FRANKLIN MANUFACTURING COMPANY

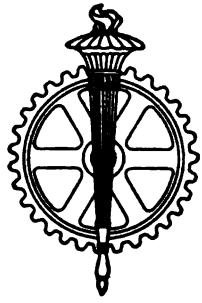
IN COLLABORATION WITH

REGINALD TRAUTSCHOLD, M.E.

WITH A FOREWORD BY

CARL G. BARTH

SENIOR MEMBER, CARL G. BARTH AND SON



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NEW YORK

TO

THE MEMORY OF

FREDERICK WINSLOW TAYLOR

Scientific Management fundamentally consists of certain broad general principles, a certain philosophy, which can be applied in many ways. . . .

FREDERICK WINSLOW TAYLOR.

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FOREWORD

To those whose good fortune it will be to read Mr. Babcock's exposition of the introduction and development of, and the results obtained by, the Taylor System of Scientific Management in the Franklin plant, it will be evident that the same is no small gratification to the man whose privilege and pleasure it was to start the ball rolling there, and to give Mr. Babcock his first practical lessons in Scientific Management.

The Franklin plant is, to my knowledge, the best example of what experience has taught me to look upon as the only sure result-producing method of going about the development of a system of Scientific Management in a plant. As such it lies between the two extreme courses that are usually resorted to by plant managers; namely, the one in which some real or pretending expert is hired to spend all his time at a plant to "put the system in"; the other, in which a local man of unusual ability is appointed to do the same thing, after fit-

ting himself by the study of the literature of Scientific Management and by visits to other plants which are supposed already to be operating in part or fully under Scientific Management.

At the Franklin plant my function was thus practically only that of an instructor and trainer of a few of their own employees, with Mr. Babcock as their leader, in the principles and details of the Taylor System. Hence, after Mr. Babcock had caught the spirit, grasped the fundamental principles, and been initiated into the general ways of applying these through a set of physical mechanisms that were the best devised up to that time, my main usefulness to him and his company were at an end.

Since the discontinuation of my regular visits to the plant, Mr. Babcock, possessed of unusual ingenuity and unbounded enthusiasm and capacity for work, coupled with the opportunity afforded for undivided attention to the particular problems of the one plant, has therefore been able to make improvements and developments in some of the mechanisms of the system that mark a distinct advance, not only over anything Doctor Taylor originally had to hand over to his direct disciples and co-workers, but also over anything that these have been able to do along similar lines, compelled as they have been to divide their attention, at the same

time, between several plants representing a diversity of products and problems.

It may be well to mention here that Doctor Taylor himself, some fifteen years ago, in warning a group of men against mistaking his details and mechanisms for essentials as against the principles of which they were merely an expression, made the prediction that, ten years from then, not a single one of those details was likely to be in existence; and while this has not fully come to pass, it is true that, for instance, I myself have hardly left any of them untouched, without, however, having made a single such decided departure as Mr. Babcock has made in the construction of his unique and truly wonderful control boards. In connection with this, I warn the reader, however, that the same are not suitable to a diversified product, though eminently superior to anything previously devised for the same purpose and particularly so in connection with a one-sided product such as the Franklin car, which, except for its two or three different styles of body, is now absolutely a single standard for one or more seasons at a time.

The failure to realize and grasp the principles behind the details and mechanism of the Taylor system on the part of a number of its students who have attempted to practise as experts, has inevitably resulted in undeservedly discrediting the sys-

tem; but I also take this opportunity to warn the reader, rather to leave it entirely alone than to attempt its introduction without the proper kind of expert instruction and guidance, and unless he can turn over to that expert a man who has at least some of Mr. Babcock's qualifications, the most essential of which is the ability to grasp and steadily keep in mind fundamental principles, coupled with great capacity for work and details.

In Mr. Babcock's formula for the determination of a man's base rate, we also have the first attempt to consider this matter from all possible angles, with a view to absolute justice.

While Mr. Babcock has fittingly dedicated his book to Doctor Taylor, it is to be deplored that Dr. Taylor did not live to learn all about what Mr. Babcock has done for the furtherance of his life work, though he did live long enough to learn that the work at the Franklin plant was proceeding satisfactorily under Mr. Babcock's leadership.

CARL G. BARTH.

November, 1917.

Dr. Frederick W. Taylor thus established a criterion by which to judge and value management. "The principal object of management should be to secure the maximum prosperity for the employer, coupled with the maximum prosperity for each employee." Major George D. Babcock, in "Taylor System in Franklin Management," describes step by step the conversion of an already successful and well-managed business into one of greatly increased activity under five years' application of the Taylor principles of management. During this period, the output of the plant has increased several fold, production costs have very materially decreased and the workers have prospered to the extent of an average increase in wages of some sixty per cent.

The conditions existing in the Franklin plant in 1908, the year in which the introduction of Scientific Management was first taken under advisement, are ruthlessly criticised by Major Babcock, though they were very similar to those existing today in many so-called successful and ably managed factories and far more satisfactory than the conditions to be found now in the great majority of our industries. In fact, so unessential was considered any change in the methods of Franklin management that over four years were devoted to investigations of results secured in other

plants operating under Taylor Systems before the decision was finally arrived at to incorporate them into the Franklin management. A comprehensive summary of the inquiries made during these four years of search for irrefutable evidence of the merits of the Taylor System forms an illuminating introduction to Major Babcock's description of the assimilation by the Franklin management of Doctor Taylor's principles.

Doctor Taylor's four great underlying principles of management—first, development of a true science of management; second, scientific selection of workmen; third, scientific education and development of workmen; and, fourth, intimate friendly co-operation between the management and the men—are then taken up individually and collectively and their practical application to the activities of the Franklin Company described. The development of the science is traced from the classification and standardization of product, methods, materials, tools and even of accounts through the establishment of control, with its divisions of responsibility and authority, the establishment of the manufacturing schedule, the centralization of the various individual despatch rooms into one main clearing department, connected to all parts of the shops through a system of pneumatic tubes for the conveyance of all shop communications, etc., and the introduction of the Control Boards to act as guides for the carrying on of all necessary acts in the conduct of the business.

The selection of the workmen and their training are taken up in the chapter devoted to employment and rate fixing, and the co-operative features of the management, while traceable throughout the development

of the science and selection and training of the workers, are explained in greater detail in the discussion of the organization, which also deals quite extensively with the specific duties and responsibilities of the various individuals—in the shops as well as in the more executive and technical departments.

Thus disposing of the more important managerial considerations through the practical application of Doctor Taylor's four fundamental principles,* Major Babcock then devotes two chapters to the changes which have been brought about from a true appreciation of the great truths of efficient, economic and equitable management. First, he dwells on the changes in product and methods, the improvements in which are indicative of the increased prosperity of the employer and measure, therefore, the benefit accruing to the organization from the new form of management; and second, he takes up the changes which have affected the men, the permanency in employment, increased wages, shorter working hours, increased knowledge of shop practices and office methods, and the spirit of friendly co-operation and loyalty which has grown up in the attitude of the workers toward the management, all indicative of increased prosperity to the employee.

* *First.* The development of a science for each element of a man's work, thereby replacing the old rule-of-thumb methods.

Second. The selection of the best worker for each particular task and then training, teaching and developing the workman; in place of the former practice of allowing the worker to select his own task and train himself as best he could.

Third. The development of a spirit of hearty co-operation between the management and the men in the carrying on of the activities in accordance with the principles of the developed science.

Fourth. The division of the work in almost equal shares between the management and the workers, each department taking over the work for which it is the better fitted; instead of the former condition, in which almost all of the work and the greater part of the responsibility were thrown on the men.

A final chapter presents in graphic form the growth and activity of the plant under the new management, the improvements which have resulted and the benefits realized by the organization, from the viewpoint of both employer and employee. The remarkable constancy in management is strikingly brought out in the equity with which the benefits resulting from the development of the business have been apportioned so as to represent increased prosperity for each employee, as well as for the employer.

This last chapter also further brings out the soundness of the principles underlying Scientific Management by showing how it has been possible completely to wind up a successful business devoted to the manufacture of one kind of product and successfully to start a very much larger business devoted to the manufacture of another product which required new designs, new tools, new equipment, new methods, a very large increase in the number of workers with workmen who manifestly could not be familiar with the new work nor possessed of that skill acquired by the men trained in the economical manufacture of the older product, and with an ever increasing volume of output. And this all within a period of a few months and without interruption to the steadily growing prosperity of the workers or to the expectancy of greatly increased prosperity on the part of the organization through the material expansion.

The appendixes, which are of quite as great interest as the book proper, Major Babcock employs for the consideration of certain details, the working out of which has been in large measure instrumental in the attainment of the very gratifying results at the Franklin plant. In the first appendix, the determina-

tion of the wage rates in the Franklin shops are discussed—the fundamental base rate, the allowances made for increased cost of living, the rewards for acquired skill, the loyalty developed through years of continuous employment, the valuable knowledge gained in methods of manufacture and the penalties which are imposed for tardiness in reporting for work, absences, spoiled work and acts detrimental to the interests of the organization are all taken into consideration in determining the wage rate of the worker. Each one of the affecting factors is valued and equated in a comprehensive formula by which the wage rate for each workman is ascertained each three months. The justice of this scientific determination of a man's wage rate has been established beyond question of reasonable doubt by the whole-hearted co-operation, contentment and satisfaction on the part of the men during a period in which the cost of production has decreased as steadily as the wages of the workers have increased.

In the second appendix, managerial schemes for the application of Scientific Management to a repair shop, a small parts factory and to a plant with uniform manufacture under Control Board operation are discussed in detail. All necessary acts for carrying on in an economical manner the conduct of each class of industry are described, with an explanation of the forms, order blanks, etc., which simplify and control the managerial acts, the authority and proper responsibilities of each department are briefly outlined and also, as far as possible, the particular duties of each individual, managerial or clerical. Thus the experience gained by Major Babcock is made available for a very large variety of manufacturing enterprises for which the managerial control as developed for an in-

tricate product such as that built by the H. H. Franklin Manufacturing Company might be too complex.

Doctor Taylor's eminent co-worker, Henry L. Gantt, has prophesied the failure of anyone attempting to introduce Scientific Management according to any set rules and by the use of established forms and blanks, without a thorough comprehension of the principles upon which it is based, and Doctor Taylor himself stated that Scientific Management consisted fundamentally of certain broad general principles which could be applied in many ways. Excellent and deserving of attention are these warnings, but the careful reader of "Taylor System in Franklin Management" should be able to approach the introduction of Scientific Management into almost any plant, not only with a thorough appreciation of the principles upon which it is based, but—aided by Major Babcock's comprehensive description of applications of these principles to factory management—with a very clear idea of how the broad general principles should be applied.

Major Babcock's very marked success in the managerial line has won for him signal recognition, for, before the appearance of this volume, he was called to the colors in France to introduce his principles in the Ordnance Department of the United States Army.

REGINALD TRAUTSCHOLD.

November, 1917.

THE TAYLOR SYSTEM
IN
FRANKLIN MANAGEMENT

CHAPTER I

FACTORY CONDITIONS IN NINETEEN HUNDRED AND EIGHT

THE year 1908 marked a critical period in the H. H. Franklin Manufacturing Company's development, for it was in that year we commenced the investigations which have culminated in our present system of shop management. The business slump of 1907, which had been acutely felt by the whole automobile industry, had been successfully weathered by us, and a decided reaction had commenced with the spring of 1908. There was a steady increase in business, but accompanied by a trying period of readjustment. Orders and cancellations followed each other with startling rapidity, though the net result invariably proved to be a gain. A similar experience was quite probably common to many, if not most, successful automobile manufacturers, and the vital problem confronting us became one of *production,* rather than one of marketing our product.

At that time our factories contained some two hundred thousand square feet of floor area, the result of a steady and healthy business growth of six years.

Production rarely exceeded one hundred cars per month, and averaged somewhat less. The factories and equipment were modern in every respect, and we were not burdened with obsolete methods. Briefly, we were what was considered then, and would be so considered today, an example of a thriving business in a growing and important industry.

The factory management, which was generally accepted as up to date and well developed, was about as follows: The management ordered the quantity, the form, and the date the product was to be finished. Through the engineering department the detailed part forms, the kind of material, and the combination of assemblies were specified. The foreman and superintendent planned for the time and duration of operations, the kind of machinery and tools, and the general operating method. They also selected and rated the workmen, and supervised their attendance.

From the general car schedules, detailed schedules were made and delivered to the foreman. These were merely copies of the original schedule of finished product, but were dated earlier by one, two, three, or four months. From this dated schedule, any foreman was obliged to plan the procedure for each mechanical operation. With these conditions, it is evident that the scheduling eventually rested in the hands of the stock chasers who represented the assembly floors.

Foremen assigned individual jobs to the workmen, supervised them at their work, and discharged them without appeal on any pretext. They further ordered repairs for machines and equipment, and selected and maintained tools and supplies.

The foremen and workmen decided mechanical methods to pursue at the work, the number of pieces

to start on each operation, and the time in which the work could be applied. *The prime responsibility rested on the workman,* with the foreman as a close second. This is evidenced by the considerable workman labor turnover on the charge of "unsatisfactory work," while there was very little change in foremen.

The result of this, as we now see, could hardly be unexpected. The plan of dual responsibility showed the usual weakness of indecision in emergency, lack of correction for faults due to uncertain responsibility, and doubt and distrust due to lack of knowledge. Opinion was pitted against opinion, and a general feeling of indefiniteness permeated the factory.

Dates called for by the management were not kept by the foremen, primarily because of the uncertainty and irregularity in the scheduling of operations. Material shortages were frequent. Tools were unsuitable and lacking. Machines were not best suited to the purpose and were often in poor repair. Neither tools nor machines were standardized, and work could not be exchanged rapidly from one to another. Shortages of parts were constant and serious, and caused a very high ratio of preparation to operating time; through this inefficiency a resultant high peak of workman effort was caused.

The change in the number of employees was frequent. A large percentage of employees were poorly trained and irregular in attendance. The management, the foremen, and the workmen were continuously at odds over results. The purchasing department was forever rushing or holding up orders, and, of course, the people from whom we purchased suffered the same experience.

Fluctuations in labor employment varied from 110

to 200 per cent through the working year. Labor turnover, measured by the number of new men employed to maintain the force, was about four and one-quarter times, that is, approximately four and a quarter men were employed to maintain a stationary payroll.

The problem of automobile manufacture was then, and is now, quite different from that of miscellaneous manufacture. No effort leading up to the product can be credited to the company finance by sale if any one element is lacking. It is a big problem of coordination of industrial activity.

The finished units are relatively limited in quantity. The demand is seasonable, and the characteristic designs from the purchaser standpoint vary in accordance with his opinions. That is, the design of a motor car is more or less dependent upon "style." The completed unit is a large assembly which is composed of sub-assemblies of unit parts, most of which must be tested for strength, noise, and perfection of operation. The parts differ radically in material form and requirement of manufacturing method. The period of planning and work for the output on account of this will range from 300 to 150 working days. The product in service is subjected to extraordinary exposure, not only to the elements, but also to strains arising from operation.

Schedules of finished output were set for a long time in advance, and were reasonably adhered to. Changes in design were frequent, as could be expected for a new and developing product. But with schedules and designs at hand, the output had a most exasperating way of going up and down. Cars could not be obtained when they were wanted, but were plentiful when not wanted. Of course, sales were lost,

and partly finished product was cancelled and scrapped. The employment of labor followed the rise and fall of the output curve. Wage increases were sometimes granted on request. Costs were high, and consequently the sale prices were higher.

The conditions imposed upon the shops at that time were no different than now. Schedules were as sure, and for as long a time, and designs were prepared in time then as now. Our industry was, compared with the progress made at that time in shop management, highly efficient. Beyond all else, we were progressive. Our problem was then, as it is of many manufacturers today, the proper consideration of rapid production from first part to finished product; handling of sales on a varied schedule, but as uniform as consistent with economy; conservation of the capital investment and the maintenance of a low stock of purchased material because of the variety, value and probable changes caused by public opinion and demand.

Prompted more by interest and desire than for any real need, the Franklin management decided to investigate the Taylor system of scientific shop management, which at that time was practically untried except by Dr. F. W. Taylor and a few close friends in sympathy with him. Doctor Taylor was consulted as to the probability of success in applying scientific management to automobile factory control. His answer was forceful and direct—that it could not fail *if* (and this is fundamental) *the management assumed its responsibilities.* Now this was a poser. Like all other managers, we thought we did assume our responsibilities. It required five years for us to learn what he meant.

Carl G. Barth, one of Doctor Taylor's closest associates, made a careful study of our factory, and in his report advised that we had the possibility of getting the Taylor System installed for less money and in a shorter time than any concern he had previously dealt with. His reasons for this belief he enumerated as follows:

"1. Because of the fact that the suggestion to install the system comes from those actively engaged in running the works and not primarily from the Board of Directors. This is a guarantee that you will do all you can to help get it in in the shortest possible time and as economically as possible; not only for its own sake, but also because you would be blamed for having recommended going into the matter if we fail either temporarily or permanently.

"2. Because *your shop is a modern one in every respect,* and will require a minimum of expense for adapting its machinery to the work.

"3. Because you have most excellent drawings of your product; few changes, if any, will be required to make them in every respect as good as the best I have ever met with.

"4. Because your product is of a more limited variety than any manufacture I have met, and will cost but little to symbolize in accordance with our system and at a minimum for time study and rate setting.

"5. Because you have already collected the greater part of the information needed for the routing of this product through your works in accordance with our methods.

"6. Because you have already a system of inspection of this product and, best of all, a special inspection room to which part, at least, of the product is

actually sent. This can readily be lined up with our way of handling the inspection.

"7. Because you have a good storeroom for general supplies and good methods for keeping track of them which can easily be switched over to our way of handling. However, I anticipate considerable difficulties with all the finished parts and supplies you have scattered about the factory in various ways, for all such stuff must be absolutely inaccessible to workman until finally delivered by the storekeeper for use on definite manufacturing orders, or directly for shipment.

"8. Because you will not have to build a planning room, as your present shop office is large enough to be used for this purpose.

"9. Because you have in Mr. ———— a man who can readily be released from all other work and can give his whole attention to learning the work for the system, and be its guardian and exponent when fully installed.

"In view of the foregoing, I fully believe that the system can be installed in your works in much less time than I suggested in my first letter to you before I visited your plant—say anywhere from twenty-one months to two and one-half years—with less of my time than ten days a month during the latter part of the time.

"Therefore, I estimate, the entire cost to you for installing the Taylor system of management would be composed of the following items:

My personal services.

Other specially hired men to assist in the installation of the system—a few of them only to remain permanently and, therefore, chargeable to

the installation of the system for, say, another nine months or a year.

New printed forms.

Special fixtures and apparatus for the planning room.

Rearrangement and reorganization of the tool room — including stamping of symbols on all tools, etc.

Alterations to the general supply room—properly including the accounting and tagging, etc., of materials now scattered throughout the shop.

Additional foremen for, say, four to eight months.

A special machine for grinding lathe and planer tools and, perhaps, for boring cutters.

Additional small tools of all kinds for emergency purposes.

Re-speeding and other alterations to machines.

"The last three items above are good investments under all conditions and are hardly chargeable to the installation of the system, but by it they are definitely shown to be highly desirable.

"These investments would, of course, begin to affect the cost reductions and other substantial savings long before the work is actually completed."

It requires an acquaintance with Mr. Barth to appreciate fully the value of his report. I have seen men who talked little and said much, but never a man who talked so much and never wasted a word. His life is full of facts, and his words are freed from husks. Some years later Mr. Barth became our guide and we never went astray.

Chapter II

INVESTIGATION OF THE TAYLOR SYSTEM

THERE are many modern plans of industrial management which would be successful if introduced at the beginning of an industry. To brace up old methods, long in practice, for new ones to be introduced, requires a knowledge of business affairs quite beyond the capacity of many of the much-heralded "Efficiency Engineers." Happily, however, many representatives of modern methods are exceptionally broad and well trained. The problem which confronted the Franklin management was to pick out from those available a representative of satisfying personality and one whose methods could command confidence.

The direction of our investigation was in two fields —the writings of Doctor Taylor and his associates, and the industries in which particular application of these investigations had been made. The literature on this subject seemed at that time to be limited to two papers presented before the American Society of Mechanical Engineers by Doctor Taylor; the one, "The Art of Cutting Metals," the other, "Shop Management"—"The Art of Cutting Metals" being his presidential address.

Through correspondence with Doctor Taylor we learned that his principles of Scientific Management could be found in operation at the Link-Belt Engineer-

ing Company of Philadelphia and Chicago; at the Tabor Manufacturing Company of Philadelphia; and at the Yale & Towne Manufacturing Company at Stamford, Conn. In the Link-Belt Engineering and in the Yale & Towne plants modifications of Doctor Taylor's exact mechanical process had been introduced by the respective managements. At the Tabor Manufacturing Company, not only the principles, but the exact procedure were as established under Doctor Taylor's personal directions.

Representatives of our organization were most courteously entertained at each of the above places, but at the Tabor Manufacturing Company only was an exhaustive study made. During the time between our visits of inspection a considerable amount of correspondence was carried on between ourselves and Doctor Taylor and Mr. Barth. Our impressions gleaned in this way are shown by the following comments and extracts from the original inter-departmental memoranda and correspondence:

We found that Doctor Taylor's investigations had definitely established the fact that a time limit could be accurately set on a piece of work before it was given to the shop; the idea being that if such a relation could, beyond any question of a doubt, be accurately and scientifically established, the control of the shop could be taken from the somewhat uncertain hands of various foremen and concentrated in one highly efficient center, which would do all the planning and directing. This would leave to the foreman only the work of

(a) Carrying out the orders given,
(b) Maintaining discipline,
(c) Setting up complicated or particular jobs,

(d) Giving any legitimate aid to workmen, and

(e) Providing that all stock and tools for the next job to be undertaken by the workman were ready before the completion of the job on which the workman was engaged.

"If this control of the planning can be removed, as it now seems possible, from the foremen, one immediate advantage is gained. We are enabled to dispense with the need of thoroughly efficient foremen, at each point, who are hard to get at reasonable salaries, and are thereby enabled to pay one thoroughly efficient man a salary commensurate with his ability and sufficient to retain him.

"At this time it might seem that with a few foremen only the advantage named is not apparent, but it does seem that where a considerable number of foremen are needed the saving made will undoubtedly more than equal the salary of the one thoroughly efficient man. In other words, a sufficient salary can be paid for the one man to interest a trained engineer, whereas it would not be possible to interest trained engineers for each foreman's position, as the position would not be agreeable even if the salary was.

"Under this system a workman is given *a definite task* to be accomplished in *a definite time* in *a definite manner,* and for which he will receive a *definite amount* known by him before starting the job. If, however, he does not completely fulfill all of the above conditions, he is penalized by receiving an amount less than that which he would have received had he accomplished what was laid out. Since the rate of pay, if the above task is accomplished, is considerably above the average rate for similar work, any penalty for

non-accomplishment will not reduce the average earning below that prevailing in the class.

"To secure all the advantages possible adverse shop conditions cannot be allowed and must be eliminated. This of itself establishes a certain economy.

"Under this system a workman is not only told in detail *how to do a job,* but *he is also furnished with everything necessary to accomplish it.* This means that he must be furnished with stock, sharpened tools, and proper jigs, and he must lose no time because of improper appliances. In other words, all things must be in the best possible condition.

"This is, in a way, the premium system, inasmuch as a definite time is established; but it differs from the premium system in that an exact way is laid out, and also in that a penalty is provided in case the instructions given are not fully followed.

"We are informed that in the few shops that are at present using this system the men are not antagonistic to the system, because by it their wages increase under clearly defined responsibilities.

"To establish this system, the principal things to be done are:

1. The preparation and maintenance of each tool in the best possible condition;
2. The standardization of feeds and speeds on all similar machines;
3. The providing of tool rooms with equipment of tools and jigs;
4. The mechanical operation of all jobs;
5. The establishment of standards, as for stock;
6. The settling of a definite operating time for each part made.

"Once a rate of time and pay has been definitely es-

tablished under this system it is never changed, unless the method of doing work is changed by the management. The rate of time is set so as to allow for reasonable variation by the workman; that is, it does not set an ideal rate, but rather sets a practical rate which can be attained by careful and industrious work. The methods can be established as slowly as desired.

"The seeming advantages of this system are:

A. The complete control of the shop is removed from the foreman,

B. The need of prodding workmen is removed,

C. Labor results alone are paid for,

D. Cost is decreased,

E. Output is increased,

F. Quality is increased,

G. Each piece costs a definite amount,

H. The rate of pay is definitely and scientifically fixed,

I. The amount paid for spoiled work is decreased,

J. Cost keeping is simplified,

K. Definite and detail plans are given each foreman,

L. The Production Department is given a chance to produce—something that heretofore has not existed,

M. More accurate keeping of promises is made possible, hence, the getting out of work on time."

As typical of our difficulty in coming to a final decision, our memorandum shortly preceding our visit to the Tabor Manufacturing Company can well be presented:

"In general, we believe that we are ready to recommend the adoption of the system, for in a great many points it is our opinion that the Taylor System only requires what undoubtedly should be done in every well-regulated shop. This refers principally to having all machines and tools in the best possible condition; the running of all machine tools at the most economical speeds; the provision of stock and tools ready and on the floor ahead of the workman; the supplying of workman with all that he can possibly need, either as regards instructions or tools; the taking away of the planning from a number of foremen and concentrating it in one place. On the other hand, the installation of this system would mean that all concerned with a manufacturing end would have a heavy burden to carry for probably two or three years. There would be many vexatious problems to solve, and the putting of this system in the factory would undoubtedly have its effect on the Accounting, Engineering, and Sundry Departments, in that the systems of numbering and recording drawings would undoubtedly have to be changed.

"Were we to start a new business, we would adopt the Taylor System. However, in changing a plant over, which is already running with more or less system and more or less satisfactorily, there are many questions which must be considered. There is probably no doubt but that for a time production might be somewhat hindered, although the aim would be not to have this happen, inasmuch as the system would necessarily have to be installed with the idea of preventing this. Then, too, there is a considerable expenditure to be made which must be fully considered and realized.

"If it should be decided to adopt this system, our minds must be made up to carry it through, else the major part of the money expended will, in all probability, be thrown away. There is probably no doubt that the Taylor System is scientific. We understand that the privilege of going over their plant would be extended to us by the Tabor Manufacturing Company of Philadelphia, and we believe that they would also give us some actual figures taken from their books which would tend to show whether or not the system was a success. This information would be of inestimable value in deciding whether or not the system would be installed. If the Tabor Company can show an additional profit in their business which can be traced entirely to the Taylor System, and more than balances the money expended; can show a reduction in the labor cost of manufacturing the same articles; can show a decrease in the time required to produce that article, or, in other words, increased capacity due to increased efficiency; and can also show that their non-productive labor has decreased in relation to their output, we should not hesitate to adopt it.

"This plan should not be started hurriedly, and certainly not until we have full opportunity to investigate or ask for such information as may be desired, thus reaching a conclusion entirely satisfactory to ourselves. In any event, as before mentioned, we realize that while this system would necessarily have to be installed by an outside individual, and while a large amount of hard work would fall upon that one, still not all the hard work, by any means, would come on the person installing the system; for it would also mean a tremendous amount of hard work for those connected with the manufacturing end to enforce and carry

out this system, because any new thing, no matter what it is, which tends to give the company better control is beset with more or less obstacles. These would, of course, have to be beaten down and surmounted.

"As before stated, we do not hesitate on account of the work. In fact, our hesitation, if so it might be called, is caused by our desire to render a perfectly true and unbiased statement, not the least bit colored for or against. We have written to Mr. Barth. Our letter and his answer follow:

" 'Your report of the estimate of cost of installation of the Taylor System in our shop was received and considered. A little further information relative to the subject is desired.

" 'Would it be feasible to install the Taylor System in the following manner; our idea being that, should we decide to install the Taylor System, we, of course, wish to make it a success. We also wish to do it as easily as possible. Not that we have in mind the shirking of any hard work, but, when we say making the installation easy, perhaps we mean making it smooth. For that reason, we had thought it might be well to start certain standard pieces which represent a considerable value as regards labor.

" 'It so happens that the pieces for which we have the most complete detail of tools are the pieces which cost the most money to produce, or, in other words, are the most expensive pieces we machine. Would it be feasible to install the Taylor System, as you might say, somewhat piecemeal—lay the plans, and put some few certain jobs to working, and, in the meantime, secure information relative to additional jobs, all the time making the list of pieces under the Taylor System grow. That would mean that, for a considerable

length of time, we would have two systems in operation, namely, the day work system and the Taylor System; our idea being that we would like to make the installation in such a manner that it would hardly be noticed. That is, we would not at once go and build additional tool rooms, planning boards, and such articles all over the plant, but we would put them in wherever it was necessary, small at first, but in such a manner that they could be readily extended to what you consider the proper sizes should be in the end.

"'This would mean that, in all probability, you would place some assistant here to guide the work, who would gather data, issue instructions, and watch the work of installation and, when certain machines were equipped and certain jobs were ready to be put on the Taylor System, they would be put on.'

"Following is Mr. Barth's answer:

"'Answering your letter of the 15th, I will say that it is perfectly feasible to introduce task work in connection with a small group of machines only, this being, in fact, the way we always begin.

"'We must, however, provide all the tools for jobs going to these machines in entire accord with the system, which means that a *section* of the tool room must be fully organized on the system to serve these machines.

"'However, until the men fully realize what we are after, there is usually little opposition on their part, and this is always reduced to a minimum when such features of the system are first gotten well under way as do not directly affect them. Our plan is, therefore, to get the air the men breathe full of the spirit of changes and improvements, so to say, so that by the time we tackle them and their work, they have become

so used to changes that they do not resent them, but take them as a matter of necessary development.

"'If you are satisfied, temporarily or permanently, with your present office methods, they may be retained undisturbed to the extent to which they have no direct bearing on the running of the shop. I shall have to insist only that you adopt our style of time card, from which the payroll and the progress of the work may all be made up, in any manner that will most readily dovetail into your present methods; and also our forms for requisitioning, purchasing, and reporting on purchased materials.

"'I am unable to give you a detailed statement of what I propose to do for you, and send you copies of the various forms I should want you to adopt in connection therewith, for it would amount to a regular treatise on the subject, and would take months to prepare in a manner that would serve its intended purpose and not be likely to lead to misunderstandings. Besides, I propose to do nothing for you except what you may wish me to do, plus such things as might be necessary in order to accomplish it, and which we might temporarily and jointly overlook in discussing the matter.

"'The main features of our system are:

"'1. Our way of planning and routing the work through the shop, which presupposes our storeroom methods and methods of handling purchases;

"'2. Our way of rate-setting by means of slide-rules and time-study, which presupposes our tool-room methods and our methods of improving defectively designed machinery;

"'3. Our cost system, which lends itself to any degree of refinement deemed desirable, both in regards

to the details of the product and the analysis and distribution of overhead expenses;

"'4. Our general accounting methods, with monthly closing of the books.

"'Any one of these may be introduced without touching upon others now practiced by you, except to such an extent necessary to bring the old and the new into harmonious relations. However, the chances are that you could profitably reorganize everything you do, in course of time, one step at a time.'

"The Tabor Manufacturing Company was chosen as the first to be visited, because we were informed that there, through a thorough understanding and appreciation of the Taylor System, it had been put in most thorough operation. The accuracy of our information on this point was confirmed by conversing with Mr. H. K. Hathaway, Vice-president of the Tabor Company, by whose courtesy we were able to get the greatest amount of desirable information in the shortest possible time. In fact, Mr. Hathaway withstood three hours of rapid cross-examination by the three members of our party, and in every case answered every question fully and frankly.

"In order to make our visit most effectual, a questionnaire was given each member of our party several days before the trip was taken, in order to have each prepared to get definite information for our subsequent use. These questions and our answers to them are presented below.

"This Company (Tabor Manufacturing Company) makes molding machines and accessory foundry supplies—tool grinders, belt benches, etc. Certain machines are made only on order, while others are standard in design and parts. For the manufacture of the

latter, raw stock, finished parts for assemblies, and completed machines are handled on a maximum and minimum basis. In reply to a question relative to changes in specification or design, Mr. Hathaway stated that the Taylor System was essentially a system of standards, as to designs, manufacturing operations, tools, and time of operations, and, therefore, was naturally antagonistic to all such changes. The nature of their product was such that improvements were necessary from time to time, and these, of course, were made.

"He further added, that if changes were made, it was possible to follow and account for such changes with exactness, and that 'slip-ups' were practically impossible. The fact that this was an inflexible rule, that positively all work must be done under this system, tended to prevent the changes being made, and called for greater forethought on the part of the engineering department. The expense of such changes and their effect to delay production became very evident under this ruling.

"We will take up now the various parts of the questionnaire previously mentioned, with our replies:

" '1—How closely does the system installed follow the original suggestion of Mr. Taylor in his paper before the A. S. M. E., June, 1903, Volume XXIV.?

" 'A very recent study of Mr. Taylor's paper enabled us to note that the system at this plant follows closely, in all important details, the system outlined by Mr. Taylor.

" '2—Wherein does it differ from the above, and what local conditions seemed to make this difference justifiable? Has it since metamorphosed into a condition retaining the germ ideas of the Taylor System,

but with changed appendages, so to speak? Is it effective in all Departments; if not, why not? What plan of paying is used? Towne-Halsey, or Premium plan? Mr. Gantt's, or Task Work with Bonus? Taylor's, or Differential Piece Rate?

"'The system is effective in all parts of the plant. No orders, either for production, repairs, or renewals to plant or for extensions, are executed until they have passed the planning department.

"'The difference was marked, in that the time of starting and stopping a lot of parts was considered the important feature—no particular time was noted as to the accomplishment of each particular operation.

"'The Taylor System includes the use of the Differential Piece Rate plan in paying for labor. But in this plant they use the Task Work with Bonus plan. Not only does the producing workman receive a bonus, but the gang boss and the speed boss each receive a bonus for each man who makes a bonus and an additional bonus if all men make a bonus. Mr. Hathaway stated that the bonus to the bosses had reached a maximum of about $10.00 per week. The idea was brought out that this was an important factor in the success of the work.

"'The fundamental difference between the Differential Piece Rate and the Task Work with Bonus plans is (to use Mr. Taylor's words) that in the former the workman is not only pulled from above to make a bonus, but he is also pushed from beneath; while in the latter, the pulling-from-above influence is potent. This is due to the fact that with the Differential Piece Rate plan, the workman suffers a penalty for not reaching a certain standard by being paid only for what he does; while with the Task Work with Bonus plan, the

workman is sure to get his established day rate in case he fails to make a bonus.

" '3—By whom was the system installed? (a) By some of Mr. Taylor's co-workers? (b) By the Tabor Manufacturing Co.?

" 'The system was installed by Mr. Barth. Mr. Hathaway, who was with the Company, followed along the lines established and was assisted by Mr. Barth.

" '4—If the Company was to go through the experience again, would it handle it differently as to installment?

" 'Mr. Hathaway expressed the belief that the beneficial results of installing this system were largely dependent on the thoroughness with which the foundations for it were laid. A little hastiness or lack of experience on the part of those installing it, was likely to be paid dearly for by the employing company. In reply to our query, he said that he thought those best qualified to lay such necessary foundations were Mr. Barth, Mr. Gantt, and Mr. Cooke. He modestly withheld his own name, but after seeing what he had accomplished in his own Company, we do not hesitate to add his name as an easy fourth; inasmuch as he has been associated with Mr. Taylor in his research work.

" '5—The system is O. K. for busy times; is it also well adapted for slack times, such as the depression of 1907 and 1908? How about work not fully developed? ✓

" 'It is the policy of this Company to take men from the factory to supply the Planning Department, and most men in that department are practical mechanics. This policy gave them men qualified by practical knowledge of the shop to lay out work along thoroughly practical lines. If intelligence is used in recuperating the shop force with the right class of men,

the entire supply for this department can be drawn from the shop, especially for the planning functions. Thus, when the depression of 1907 and 1908 came and business became slack, the inefficient men were dropped from the factory list and their places were supplied from the Planning Department until a profit-making equilibrium was established, and at no sacrifice of the efficiency of the Planning Department. When business again picked up, the process was reversed, and additions were made to the Planning Department as fast as the business demanded them.

" 'The fundamental feature that the system accounts in very close detail is of the greatest aid in slack times, and the work can be placed in the shops by the centralization of supervision without the influence of the foreman acting to the contrary. This influence was common in the old system, as the function allowed the men to slow up to protect their organization. This slow-up was hard to find by the order system. Its proportion was seldom exactly known. The exact control of machines and the flexible system of routing made it possible to centralize work quickly and effectively.

" 'We consider one very valuable and important point that of interesting and using the best mechanics for clerical work.

" 'An exact knowledge of relative expenditures is an especially good thing in dull times.

" 'There was practically no such thing as "work not fully developed." It was essential that each piece be developed, and if there were not enough pieces so developed to produce the assembly, then the assembly waited until these were completed. However, the value of knowing just what was needed to obtain a proposed result was a most valuable asset.

" '6—About cost reduction: From the producing labor standpoint, how does present cost compare with that under the old system? In point of numbers and amount paid for wages, how about non-producers as compared with the old system? Or what proportion does the amount paid for unproductive labor bear to total overhead under present and old system?

" 'It was stated to us that since the installation of the system, the company's financial status had changed from a condition where it was on the verge of a change in management, if not of a receivership, to a very profitable business, notwithstanding the fact that several firms had arisen in competition during the last decade.

" 'In the present system, as compared with the old, non-producers have been increased in numbers and amount paid for wages in the ratio of about 5 to 1. In other words, they now employ five non-producers where they formerly employed one, in relation to the same amount of work. This is due chiefly to a more exact classification of non-producers, *i.e.*, a more pronounced separation of productive and non-productive work.

" 'In conclusion, a word about the investment involved: Mr. Hathaway stated that the company's investment in commercial tools alone, such as drills, reamers, milling cutters, clamps, bolts, etc., had increased from practically no investment to between $35,000 and $50,000 for the service of 125 workmen. Much more room, and a more elaborate system of tool racks and storing bins and drawers had to be provided, and in the factory at each machine facilities have been provided to take care of instruction cards and tools.

" 'The system provides a graphical view of the shops and all equipment. The capacity of any or all classes

of tools, or the retard of work at any tool, was very evident from the work board.

" 'The prevention of misplaced material was evident. The lack of materials or tools was easily anticipated, because they were scheduled at a definite time and were prepared beforehand.

" 'In brief, the company was able to decide what they desired to do, then were able to carry it out in strict accordance with previously considered and thought-out plans.'

"The main question left to be considered is: what is the proper thing to be done to make a factory organization more certain in accomplishing predetermined results? Most competent managers and superintendents can see the results that they want accomplished, and are able to get these results in just the proportion that they are able to eliminate the personal equation from the rank and file who execute their orders. Unfortunately, however, the personal equation cannot be entirely eliminated from an organization in which any ordinary system of handling work is installed.

"Evidently, a step in advance would be to subject all things to be done in a factory to some system by which each process from start to finish would be thoroughly planned by a corps of well-selected and trained minds, and one in which any deviation from the plans so made will be apparent at once and the reason ascertained, so that the desired results will not be thwarted. The Taylor System, as worked out at the Tabor Manufacturing Company's plant, comes the nearest of any we have seen or know about to fulfilling these conditions.

"In other words, as we see it, what we should have is a system of correctly specifying and carrying out work of all kinds; so that every process will be car-

ried out exactly as planned, and can be repeated as many times as desirable, in exactly the same manner and with exactly the same results, and the sum of all processes in the factory can be determined with nearly as great exactness as can be determined the sum of two plus two. This is the ideal; and the thing that will come nearest to this is, in our opinion, the thing to do."

With these facts so clearly before us, it was quite apparent that the introduction of the Taylor System would involve considerable expenditure of time and money. This could only be warranted if the outlay really promised concrete gain commensurate to the investment.

Our determination to give the system a thorough trial was made deliberately and only after a systematic review of all conditions, for it was not until July, 1912, that Scientific Management was practically applied in our plant. Exhaustive as had been our investigations, our decision was arrived at only after a thorough comprehension of Doctor Taylor's teachings and warnings, as so ably expressed in the following extracts from his writings:

"After many years of close personal contact with our mechanics, I have great confidence in their good judgment and common sense in the long run, and I am proud to number many of them among my most intimate friends.

"As a class, however, they are extremely conservative, and, if left to themselves, the progress from the older toward better methods will be exceedingly slow. My experience is that rapid movement can only be brought about through constant instruction and application of those responsible for its introduction.

"It must be said, therefore, that to get any great

benefit from the laws derived from our experiments, our methods must be used; and even they are of little, if any, value under the old style of management in which the machinist is left with the final decision as to what shape of tool, depth of cut, speed, and feed he will use.

"The instructions as to speed, feed, depth of cut, etc., must be sent to the machinist well in advance of the time that the work is to be done. Even if these written instructions are sent to the machinist, however, little attention will be paid to them unless rigid standards have not only been adopted, but *enforced* throughout the shop for every detail, large and small, of the shop equipment, as well as for all shop methods. And, further, but little can be accomplished with these laws unless the old style of foreman and shop superintendent have been done away with, and functional foremanship has been substituted—consisting of speed bosses, gang bosses, order-of-workmen, inspector, time-study men, etc. In fact, the correct use of our methods involves the substitution of our whole task system of management for the old style management, as described in our paper on 'Shop Management' (Transactions A. S. M. E., Vol. 24). This involves such radical, one might almost say revolutionary, changes in the mental attitude and habits both of the workmen and of the management, that such re-organization should only be undertaken under the direct control (not advice, but *control*) of men who have had years of training and experience in introducing this system.

"A long time will be required in any shop to bring about this radically new order of things; but in the end the gain is so great that I say without hesitation

that there is hardly a machine shop in the country whose output cannot be doubled through the use of these methods.

"And this applies not only to large shops, but also to comparatively small establishments. In a company whose employees all told, including officers and salesmen, number about 150 men, we have succeeded in more than doubling the output of the shop, and in converting an annual loss of 20 per cent upon the old volume of business into an annual profit of more than 20 per cent upon the new volume of business, and, at the same time, rendering a lot of disorganized and dissatisfied workmen contented and hard-working by insuring them an average increase of about 35 per cent in their wages. And I take this opportunity of again saying that those companies are indeed fortunate who can secure the services of men to direct the introduction of this type of management *who have had sufficient training and experience to insure success.*

"Unfortunately, those fundamental ideas upon which the new task management rests mainly for success are directly antagonistic to the fundamental ideas of the old type of management. To give two out of many examples:—Under our system the workman is told minutely just what he is to do and how he is to do it, and any improvements which he makes upon the orders given him is fatal to success; while, with the old style, the workman is expected to improve constantly upon the orders given him and upon former methods. Under our system, any improvement, large or small, once decided upon goes into immediate use, and is never allowed to lapse or become obsolete; while under the old system, the innovation, unless it meets with the approval of the mechanic (which it never does at the

start), is generally for a long time, at least, a positive impediment to success. Thus, many of those elements which are mainly responsible for the success of our system are failures and a positive clog when grafted on to the old system.

"For this reason the really great gain which will ultimately come from the use of our methods will be slow in arriving—mainly, as explained, because of the revolutionary changes needed for their successful use —*but it is sure to come in the end.*

"Too much emphasis cannot be laid upon the fact that standardization really means simplification. It is far simpler to have in a standard shop two makes of tool steel than to have twenty makes of tool steel, as will be found in shops under the old style of management. It is far simpler to have all the tools in a standardized shop ground by one man to a few simple but rigidly maintained shapes than to have, as is usual in the old style shop, each machinist spend a portion of each day at the grind-stone, grinding his tools with radically wrong curves, and grinding angles, merely because bad shapes are easier to grind than good. Hundreds of similar illustrations could be given showing the true simplicity (not complication) which accompanies the new type of management."

How wise our decision was is best demonstrated by the fact that at the present time (July, 1917), we are turning out forty-five cars per day under conditions which promise soon to tax our capacity. Our industry is prosperous and growing. We have added some five hundred thousand square feet to our factory floor space and are paying considerably higher wages to our workmen, an average increase of close to 60 per cent since July, 1912, and of 90 per cent since 1908,

while our labor charge has nevertheless steadily decreased through the cooperation of all parties. Since the day on which we commenced to develop our new management we have had absolutely no labor trouble of any kind. Our management is keen, active, and prosperous; our workmen contented, healthy, and also prosperous.

Chapter III

CLASSIFICATION AND STANDARDIZATION

THE Taylor System of Scientific Management is essentially a system of classification and standardization. It is that kind of management which *conducts* a business or affairs by *standards* established by facts or truths gained through *systematic* observation, experiment, or reasoning.

It is quite different from *Common Sense Management,* which relies upon native practical intelligence, natural prudence, tact in behavior and the generally accepted attributes of good management, in that it is based upon acquired learning and logical speculation. The virtues of the older system are not discarded, nor in any sense discounted, under Scientific Management. They are, on the other hand, incorporated and assimilated coordinately with acquired and carefully investigated knowledge to form a comprehensive system of cooperation between management and producer. Careful and systematic classification and standardization of methods, materials, tools, and products form, therefore, the first requisite for the installation of Scientific Management.

During the period of installation of Scientific Management, and until the business has been under such conduct for a considerable time, first standards are naturally roughly approximate to what the standards

will eventually become. It is natural, therefore, to expect a very close intercourse between all of the interested parties during this development. The approximate standards of an old business must be revised, and the varying rapidity of approach in different businesses to highest standards precludes the assumption that any particular form of installation or reconstruction can be used by the industrial engineer, or those parties affected by his counsel.

Unless the difficulties through the period of dissolution of established practice and the development of new be overcome by persons who have the interests of the business at heart and are guided by the most intelligent persons obtainable, the approach to failure of the business, as well as of the methods, is sufficiently rapid to cause great concern, if not severe losses, to organization and finance.

Preliminary to any active work, the management and the more important supervisors and workmen must at least agree to be in accord with the intended changes and give their unqualified support. Those chiefly responsible for the work of reorganizing will mark most deeply the final results. If they conduct the work in a half-hearted or unscientific way, conditions will be much worse than before they started. If they are capable and are supported, it will eventually be carried to a successful conclusion and bring a sense of comfort and lack of discord which the organization has hitherto unknown.

Classification of product, materials, and machines ordinarily comprises the first task—a most important one, for it forms the backbone of the entire system. The recommended order in which this should be done and the scope of the work is as follows:

I. CLASSIFICATION OF PRODUCT

The different kinds of units sold are recorded. Each of these units, if composed of two or more parts, is then completely analyzed, first, into its largest group, then, each of these groups into the next largest groups, and so on, until individual or single parts are all listed. In the separation of these units into their subdivisions, there is a natural division of parts into two classes; those that are purchased finished ready for use, in one class, and those that are to be manufactured, in another class. Of the parts which are manufactured, there may be two classes; one class in which the parts are assemblies of several pieces, and the other class, single parts which fasten the assemblies together.

As the units are disassembled, a record is compiled of the order in which this occurs. The inverse of this is naturally the order in which the parts shall be assembled. A chart (Figure 1) of this classification is then developed, showing this order. When the simplest and most economical form is determined, it is adopted as standard. It is important that standard designations, or index numbers, be applied to each part and assembly. One most common in old methods was a drawing number, or, as called by some, a pattern number.

This use of a drawing number as a designation symbol is not always to be recommended, for, unless the drawing numbers are applied in consecutive order to the parts as they are assembled, they do not provide a logical and easily remembered classification index, but simply an arbitrary designation which may tend to confuse.

There is no reason why the Dewey decimal system could not be applied to the classification of product,

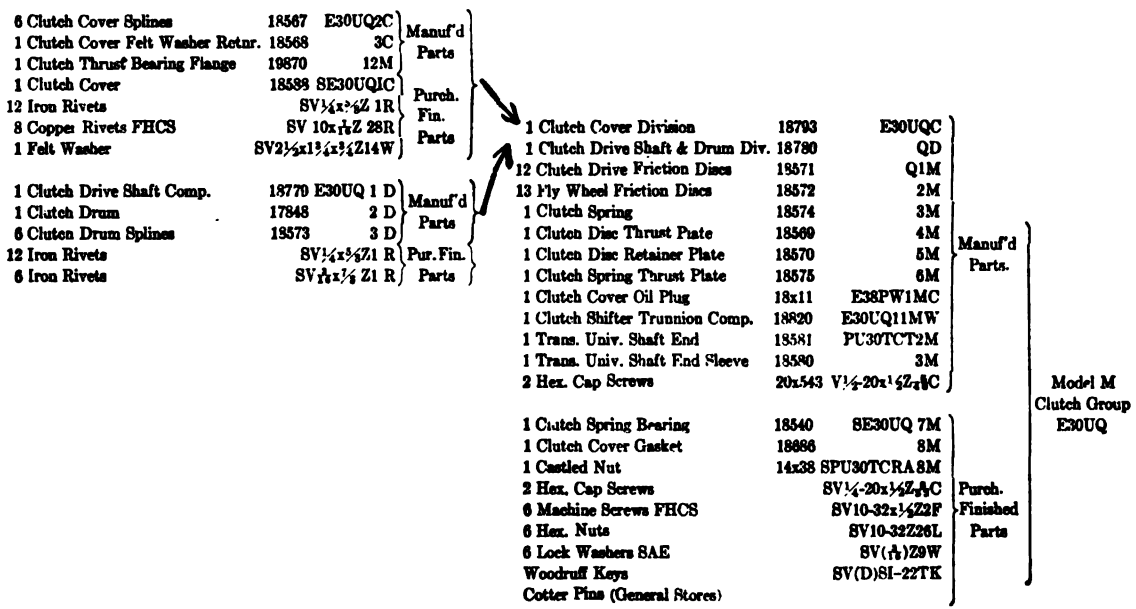


FIG. 1. CLASSIFICATION OF CLUTCH ASSEMBLY

however, and accomplish a very superior result in its development over that of the drawing number, but only by the phonetic form of classification, in which letters which approximate some characteristic sound of the part are used, will the greatest convenience be obtained.

II. CLASSIFICATION OF METHODS

Since different procedure must be followed in establishing methods in various businesses, it is evident that a complex business must be analyzed and classified into simpler forms better to study and to provide for the requirements of each.

The chief product of an automobile manufactory is—the automobile. After several years of production, however, the making of repair parts for current[1] and non-current models[2] becomes a necessary addition, and also factory repairs[3] to customers' cars.

Standards for one division vary greatly from the other two, and, unless separated, the best result for each will not be attained. Our methods have been applied separately and differently to each of the three divisions mentioned. The principles of conduct are the same, but the standards for each have different values.

III CLASSIFICATION OF MATERIALS

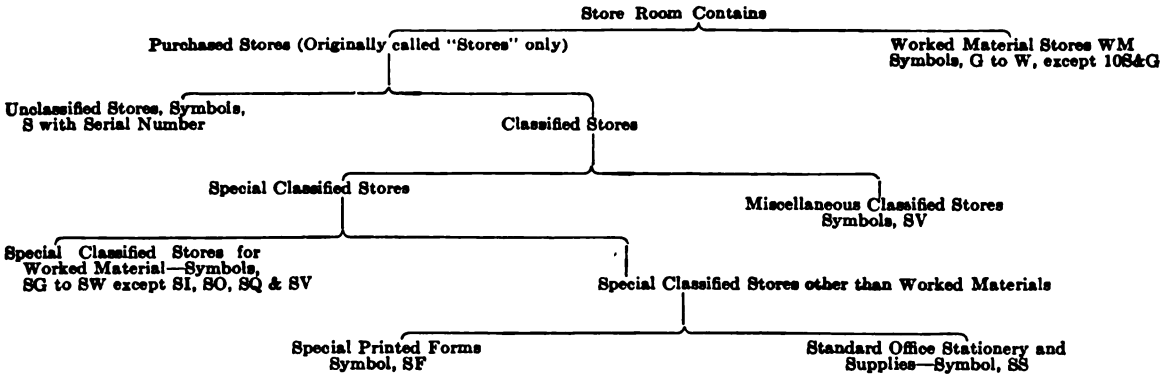
In manufacture, an assortment of finished materials and parts are required to be on hand at all times. Some of these may be used for direct production purposes, such as bar and sheet stock; others, primarily for assemblies, such as fastenings, linkages and finished shapes; another kind, that of perishable supplies,

such as waste, sand-paper, and lubricants; still another, stationery supplies. These fall into natural divisions, which are best indicated by the accompanying chart (Figure 2).

In the "special classified," those parts are arranged which are purchased, but are made to the manufacturers' orders. The "miscellaneous classified" (our classification of which is shown) is the most complex of all, and represents the most common of materials. Few of these common materials have standard designation by those who produce them. It is not at all uncommon to find entirely different forms of expression used by different persons to describe the same article, and it is very noticeable that the most insignificant things require the greatest effort to describe.

After the materials are completely classified and standardized, the arrangement of the materials in the storerooms is according to the classification, very much as are the books in a library. Fastenings will be found in one division, bar stock in another, sheet stock in another; so that merely a designation of the article immediately indicates its approximate location to the experienced stock man. This saves a great amount of wasted effort in the filling of orders.

Such classification of materials makes one of the tangible assets of the business most presentable in the financial statement. This is because the arrangement of the storeroom records agrees with the classification of materials. A materials-ledger inventory can be very quickly drafted, and the distribution of value of materials readily determined. "Special classified" materials are not marketable except through the process of manufacture, while "miscellaneous classified" are available for immediate sale.



MISCELLANEOUS, CLASSIFIED STORES

SV-A Miscellaneous Stores not elsewhere classified.
SV-B Brass, Bronzes and Copper and products made principally from these metals and their alloys.
SV-C Cast and malleable iron products, including steel pulleys, knobs for jigs, pipe fittings of wrought iron, and Millwright's supplies.
SV-D
SV-E Electrical materials.
SV-F Fuels, such as steam, coal, hard coal, coke, charcoal, gas, any fuel used.
SV-G
SV-H General Hardware
SV-HE Class (11) Motor Car Equipment.
SV-K
SV-L Liquids and semi-liquids, such as paints, lubricating oils, greases, soft soap, acids, tar and chemical compounds and mixtures.
SV-M Miscellaneous metals, not elsewhere classified, including aluminum, iron, babbitt, etc., and products made chiefly from these metals.
SV-N Materials and mineral products, other than metals.
SV-P
SV-R
SV-S Steel and wrought iron in form of rolled, drawn and hammered products.
SV-T Tools and mechanical implements not included in Tool Room Classification.
SV-U Upholstering Materials.
SV-V Lumber.
SV-W Products made chiefly from wood.
SV-X
SV-Y
SV-Z Fastenings, such as bolts, nuts, rivets, nails, hasps and hinges not such as are used exclusively for upholstering, which are to be placed in Class SV-U.

FIG. 2. CLASSIFICATION OF MATERIALS

IV. CLASSIFICATION OF MACHINES

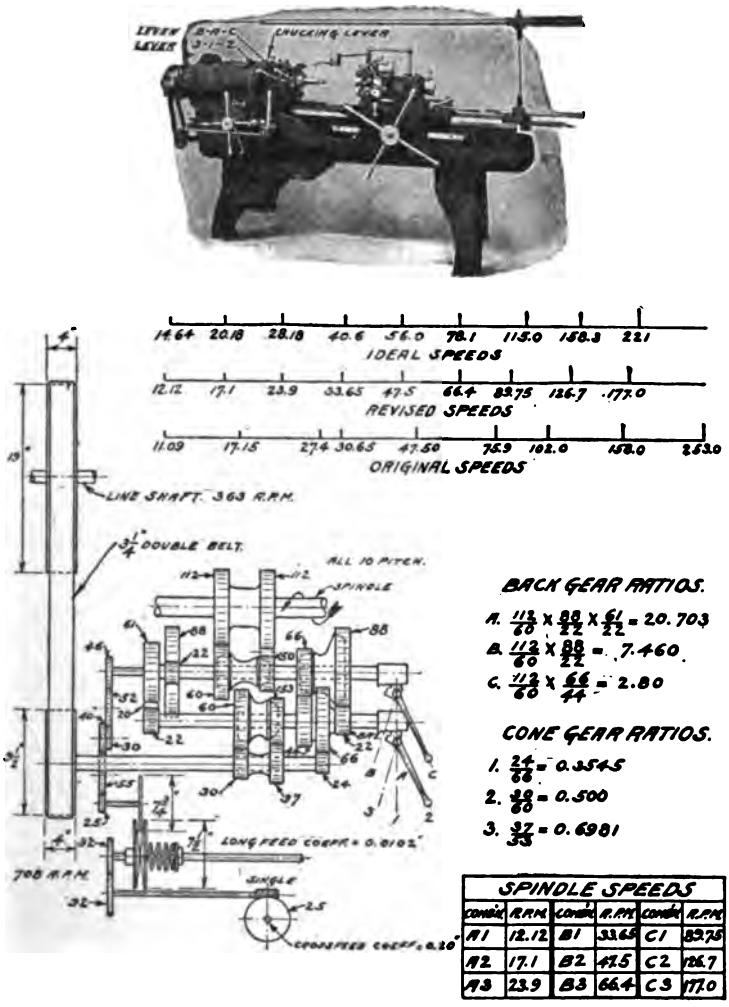
In a complex mechanical industry, a large variety of machines are used. Among the more common ones are punch presses, turret lathes, automatics, grinders, milling machines, and drilling machines. Many types are in each of these classes. Where a large variety of parts are manufactured in relatively small quantities an arrangement of machines by groups of common class is an economical one. To route parts over their many operations, and to be sure that the productive burden on a machine does not exceed its capacity in the hours of work, it is essential to know the number of similar machines in a class, the number of the different types, and the particular location of each machine.

Automatics are naturally divided into two types, semi-automatic and full automatic. Drilling machines into power, multiple spindle, and sensitive. All of the machinery, therefore, is classified into its most general class, then into sub-classes, then into types, and finally to individual machines. Not only are machines and all equipment classified and symbolized, but identical types are standardized for exact interchangeability.

It is not uncommon to receive machines from the best machine-tool makers in our country that are reported to be exact duplicates, but upon which it is impossible to exchange identical tools and obtain the same result. A slight variation in turret height on a turret lathe, or the least difference in spindle thread, in gear ratio, or in pulley diameter, will preclude exact interchangeability, and such machines must be mechanically standardized and so maintained.

The principal standard that must be determined for practically all machinery is the percentage of increase

in speed over each speed change by the cones or gears. The standard promulgated by Mr. Barth, which we adopted, was such that the change of speed from one



SPINDLE SPEEDS

cones	R.P.M.	cones	R.P.M.	cones	R.P.M.
A1	12.12	B1	33.65	C1	93.75
A2	17.1	B2	47.5	C2	126.7
A3	23.9	B3	66.4	C3	177.0

FIG. 8. CLASSIFICATION OF MACHINES
Single-spindle turret lathe and diagram of "Revised Gearing"

step to the next increased in geometric progression. The diagram (Figure 3) illustrates a well-known make of machine completely analyzed. The increments of speed are shown before alteration and after alteration. Such diagrams have been prepared for all of the machinery which we use. It is evidently a very simple matter to determine the exact speed which can be obtained on any particular setting of the machine. So, if a certain rate of cutting of machine tool has been determined and the work is to be done on a particular machine, it is possible for the planning department, through this record, to set the time which will be required. From the study of this diagram it is evident that not only must the line-shaft speed be standardized, but, if electrically driven, even the voltage of the supplying line must be maintained constant. In fact, our power plant department is not infrequently brought to task on account of reduced voltage by our learning that a certain group of machines fell a definite percentage below the speed at which they were to be operated.

V. STANDARDIZATION OF MECHANICAL METHODS

When the classification of product is arranged, each part must be analyzed to determine the mechanical procedure. This procedure is then adopted as standard. A part in process must move from machine to machine in the exact order as recorded, unless a temporary suspension of standard is authorized by the manager. That is, if the order of work would be:

Operation 1. Automatic
" 2. Milling
" 3. Drilling
" 4. Heat Treating
" 5. Grinding,

there will be no exception to this order except by special authorization.

The mechanics who established this routing did so with the complete understanding of their problem, and, although there may be another way "just as good," such a substitution could cause mechanical troubles and disorganize the control.

To follow certain mechanical methods, the kind, form, and amount of material must be known to the factory mechanic. If he has an elaborate and costly preparation method, he is best able to determine the least number of pieces which should go over that operation at one "set-up." So the size of lot has been standardized for each operation. The same lot size on the same operation on the same, or similar, machine will be produced in the same time. A definite *producing time* for each operation is thus established, to which is added a reasonable allowance to assure the completion of the operation in actual production work within the *allowance time* thus fixed. The allowance time for each individual operation on each part is definitely set and the allowance time for all operations on each lot of a particular part, or assembly, may be arranged in their consecutive order—*i.e.*, the allowance time for each operation on a part listed in the consecutive order in which the various operations are performed.

Figure 4 illustrates diagrammatically such arrangement of allowance times for a particular part as displayed on our Control Boards. Each of the square blocks, or cages, represents a particular operation on the part, and the space following each cage (the space between one cage and the next cage to the right) is proportioned to the allowance time per lot for the par-

ticular operation. The space occupied by the cage itself, representing on our Control Boards one working day, is the time allowance between operations allotted to the moving of the work to the machine on which the next operation on the part is to be performed, setting-

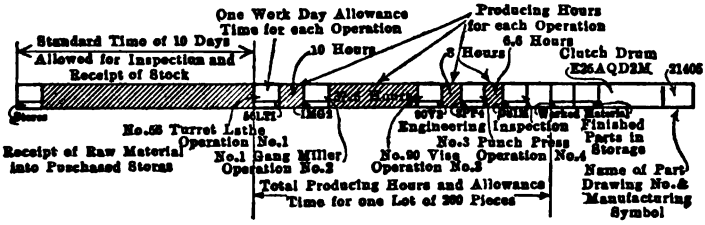


FIG. 4. STANDARDIZATION OF MECHANICAL METHODS
The basis for the Control Boards

up, etc., while the space measured over all represents the time the lot is in the shop. Preceding the first operation cage, the space is proportioned to the time required for inspection and receipt of stock from stores.

A similar arrangement for each part and all assemblies, as in classification of product, is made and mounted on a Control Board (Figure 5), and establishes complete standardization of all mechanical methods. A more detailed description of the Control Boards, their function and operation will be given in Chapter V.

VI. STANDARDIZATION OF TOOLS

Jigs and fixtures which are special to the part for which they are used are standardized, as far as possible, in design and construction, and are naturally classified and arranged in the tool storeroom according to symbols which agree with lists specified for each mechanical operation. In addition, there are the numerous small tools which must be employed, such as

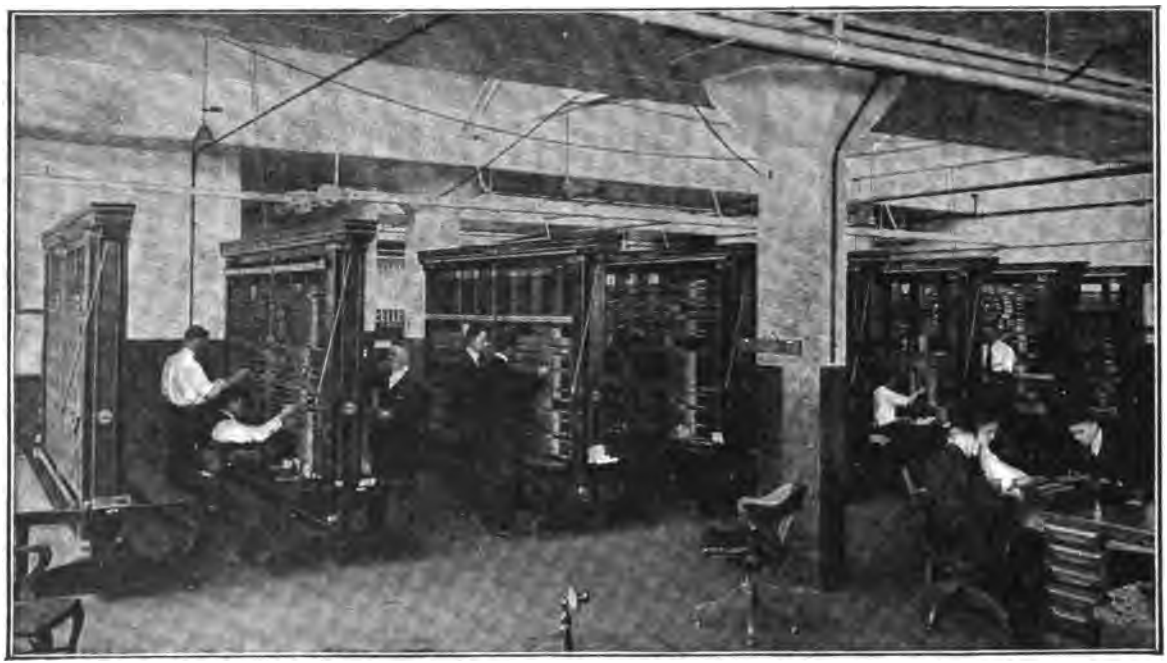


FIG. 5. THE "CONTROL BOARDS" USED IN THE FRANKLIN PLANT
Detailed description of the operation of these boards will be given in a later chapter.

drills, reamers, milling cutters, grinding wheels, etc., and these have to be standardized and a reasonable stock maintained. This makes it imperative that certain kinds of each class be adopted as standards for use and that only such tools be employed. The natural inclination of the mechanical man is to try every known make of drill, for instance, especially those of unusual and frequently useless form. For his protection, as well as to make the attainment of an efficient standard possible, it is necessary to limit his privilege in this respect. The decision as to what variety of these tools should be used is left to our Routing Department. Its decision is final, and fixes the standard, which cannot be deviated from, excepting when the standard is changed. Such alterations cannot be made without the most careful investigation and the cooperative judgment of management and workmen.

How important is this rigidity of standard can be exemplified in no stronger way than by the fact that Doctor Taylor and his associates spent the best part of thirty years in reaching a conclusion as to the standardized form of the cutting edge of simple lathe tools. So much effort is required to obtain even such an apparently simple determination that once obtained it must be put into practice and adhered to. Since the chief use of machinery and men is merely to force a small cutting edge through refractory materials, and since the energy of the entire combination is concentrated upon this very limited area, that is, the edge of the tool, any possible effort put forth for an exact determination of the most economical form will be repaid in full by the results obtained. What is true of lathe tools is equally true of all other perishable tool supplies.

FIG. 6. ARRANGEMENT OF A TOOL STOREROOM

Standards for tools once fixed, an adequate supply must be maintained, and all tools classified and so grouped in the tool storeroom. A view of one of our storerooms (Figure 6), in which the tools are arranged by classes according to the symbols specified for each mechanical operation, well illustrates this convenient and efficient plan.

To maintain the standard forms of cutting edges and the efficiency of the cutting tools, a tool-grinding department, equipped with numerous machines of precision, is an essential adjunct to the tool storeroom. In this department all tools are sharpened, etc., by specialists in such work, so that the tools issued from the tool storeroom for any job are in the best shape. There must be no grounds for a workman complaining of his tools.

VII. CLASSIFICATION OF ACCOUNTS

With a complete and exact classification of the various elements involved in manufacture, primarily for the sake of convenience and economy in manufacture, a classification of accounts follows as a necessity along lines similar to those mentioned above. For accounting purposes, departmental lines are drawn and a perpetual inventory is maintained for each department—buildings and real estate, machinery, direct and indirect labor, tools and fixtures, agree in the accounts with the physical distribution.

In addition to the adoption of definite classifications as standard, many other elementals must be considered. Chief among these are the route or path of production as mentioned; forms, which are essentially standardized instructions of the manager; hours of labor, rate of wages; conduct of personnel; time of manual, as well as of mechanical, operations.

Chapter IV

ESTABLISHING CONTROL

THE development of a successful and equitable form of management is essentially a science, and must be built up on definite basic laws of justice, equality and efficiency. Control must be cooperative, but nevertheless absolute. The establishing of control is then the first consideration, and naturally closely follows the general scheme briefly outlined in the preceding chapter. The adoption of a classification of product, materials and machines best suited to our individual requirements and the practical application of the standards were commenced with the cooperation of Mr. Barth as advisor and guide in 1911, although absolute control was not established until July, 1912.

Classification of product, *i.e.*, the marketable output of our industry, constituted our first step, and was somewhat more complex than would be the same task today, as, at that time, we were building commercial as well as passenger automobiles.

Due to complexities arising in the classification of the car, it was decided to treat the engine as a separate element of manufacture, so our product was classified under four divisions—Passenger Vehicles, Commercial Vehicles, Engines, and Sundry Parts. At this time (1911) Sundry Parts, *i.e.*, parts for damage replacements in customers' cars, were made on the regular

machines through the factory; consequently, with more or less job work done in the manufacturing departments, there was always possibility of interference. It was furthermore recognized that tool making, pattern making, factory repair work and repairs to customers' cars were operations not closely allied to repetitive manufacture. An investigation of the use of shop machines proved that a considerable number were used continually for sundry parts. We decided, therefore, to establish an entirely different division of work for these parts, separated physically and managerially from the main factory.

There had been a belief that sundry parts work provided a useful burden for the regular factory machines during forced idleness for lack of productive materials or of uneven control. Under the old managerial methods this was undoubtedly true, but was found unnecessary and a positive trouble when the machine burdens were exactly calculated and the control was in force to require such burdens. That is, through intensive control it was entirely possible to so regulate machine burden that the percentage of idleness was no greater without sundry production than with it, and the machines which were taken away from the main factory and set aside for this purpose were used to better advantage for economy and service.

Tool and pattern making and factory repairs were also segregated and eliminated from the control plan of the automobile shops. This does not mean that they were set aside without a particular supervision, but that a very definite exact form of control was provided for these separate shops, as for the main works.

With this policy established, a classification of the motor car product was made. The classification of an

engine is typical. An engine and a complete set of drawings with a bill of materials was set aside for analysis. The Route and Operation Department, the foreman of the engine assembly, and an observer then completely dissected the engine and made detailed notes of the sub-assemblies which could logically be built as such; and noted and listed all fastenings such as screws, washers, etc., including even binding wire. The drawings were studied in conjunction with the engine, and both were worked over until it was evident that at least a very close approximation to best methods and best procedure had been determined. A complete classification diagram for the engine was then laid out, much as described in Figure 1, Chapter III. The assembly drawings were modified until they exactly agreed with the physical assembly. This required considerable change of drawings from the form in which the engineering and experimental departments developed them for their uses and for the shops, but it brought about a very desirable result. The foreman, the workman, and the routing department knew exactly from the drawing what parts would appear in the physical assembly. It is now known that the drawing of a particular part or assembly requires exactly what is shown on its face and no more. The drawings were further changed, so that the bill of materials appeared only in the drawing, with a specification in the margin for chemical analysis or material index number.

Each part in the assembly was indicated by a symbol which, as far as possible, reflected by sound the assembly in which it was used, *e.g.,* the assembly PU30TCAS meaning (P)assenger Vehicle, Model (U), (30) Horsepower, (T)ouring (C)hassis (A)xle (S)pring. The latter part of the symbol rarely changes

as the models change, because it is conventional with the motor-car that a spring be used in conjunction with the axle. The horsepower symbol and the model symbol are the index of the changing product.

The spring is made up of a variety of leaves, each one a part; therefore a complete symbol of a spring leaf would be PU30TCA1S, with an index number introduced before the last letter for specific reference. Other parts which hold the spring together, purchased finished as catalogued by vendors and used for a variety of purposes, can be formed into a complete classification of their own. This will be mentioned later.

There was some question as to the advisability of symbolizing all past product, but it was decided to make no particular attempt to symbolize obsolete output. In some industries this might be necessary, but in our case we have found it not called for. For classification, we adopted our drawing numbers with a symbol for index. This has proved quite satisfactory, and it is an interesting matter of record that, on account of the rapidly changing product, three sets of charts became obsolete before we obtained a final form for classification.

The mechanical procedure, tool and equipment limits and tolerances were described for both parts making and the assembling of the product from the simplest part into the first sub-assemblies, and so on through to the completed group. No act or movement was considered of so little importance as to be omitted. No attempt was made to take time studies, due to the experimental nature and lack of repetitive work. To assume that of the many persons who performed this work, no two exactly agreed is entirely true. Each desired to do something in a particular way, but it was

obvious that there had to be a definite, predetermined agreement for all parties to work in harmony. To prevent discord, each function was given to a particular man, and with responsibility went authority.

A rough index of arrangement of work was made during the analytical investigations, which was later carefully revised and eventually standardized. That is, the procedure in all details was established and could be deviated from only by mutual agreement of all parties and with the authorization of the Production Manager. Differences of opinion were not infrequent at first, but the violation of a standard could not be allowed. When this was thoroughly appreciated by *all parties,* and then only, did it become possible for the organization to work together for exact reproduction. Of course, the best procedure was desired, but standardization was the more imperative. Eventually the best methods, or, at least, those we considered the best or most advisable, became standard; but whatever the existing standard, standard it remained until changed with the approval of the Production Manager.

The classification of variety stores constituted a trying task. All catalogues which could be obtained of the materials entering into our work were compared and classified according to the form illustrated in Figure 2, Chapter III. This arrangement soon took on such large proportions and the symbol thus developed became so complex that the scheme appears unwieldly and unnecessarily complicated. Notwithstanding its apparent cumbersomeness, however, the classification has proved eminently efficient, for it has remained in constant use, without a single exception, on all drawings of all product up to the present time, July, 1917. While apparently bulky and the symbols large, this

classification seems to be the shortest and most exact method of explaining and describing each of the miscellaneous parts entering into the make-up of an automobile.

One of the most complex symbols we employ is that for sponges, and if it had not been used continuously for five years without a protest I would be inclined to say it was unusable. The elements of this symbol—SV(2U)AT1S—are:

S—Stores
V—Variety of Purposes
(2U)—Particular Sponge indicated
A—Miscellaneous class of materials
T—Textile and Fibrous Materials not Elsewhere Classified
S—Sponges

CLASSIFICATION OF SPONGES

(Copied from a page in our classification folio.)

Symbol SV-ATS

Condition—"Bleached" and "Unbleached"
Shapes—"Forms" and "Cuts"
(Forms are natural sponge shape)
(Cuts are parts of Sponges)

The different sponges have different number of pieces to the pound, depending on the character of the sponge and whether it be in the "Form" or "Cut." The number of the sponge is the number of the pieces which will make a pound, and this number will be used in the symbol, in addition to the letter "B" for bleached and "U" for unbleached.

The kinds of sponges listed in the following table (Fig. 7) with their particular uses are standard.

There is another class of purchased parts which are

	NAME OF SPONGE	CONDITION	SIZE	USE
1-S	Rock Island Sheep's Wool	Unbleached	"Forms" 1-2 up to 30 to 40 "Cuts" 2-3 up to 30 to 40	Most durable sponge for fine carriage washing.
2-S	Rock Island Yellow Sponges		"Forms" 1-2 up to 30 to 40 "Cuts" 3-4 up to 30 to 40	Considerably harder than Sheep's Wool—not so durable.
3-S	Florida Key Sheep's Wool		"Forms" 1-2 up to 30 to 40 "Cuts" 4-6 up to 30 to 40	Look like Rock Island but considerably cheaper.
4-S	Key Yellow		"Forms" 1-2 up to 30 to 40 "Cuts" 3-4 up to 30 to 40	Look like Rock Island Yellow—much softer, higher priced.
5-S	Cuba Sheep's Wool		"Forms" 1-2 up to 30 to 40 "Cuts" 3-4 up to 30 to 40	For Calciminer's, Painters, Etc.

FIG. 7

NOTE.—"Inshore" sponges are not so firm or so good a grade as "deep-sea" sponges. The deep-sea sponges cost about 50 per cent. more than the shallow water sponges.

Other industrial sponges are Anclote grass, or Rock Island grass, key grass, Cuba grass, Cuba reef, Cuba hardhead. The grass sponges are the cheapest on the market. It may be generally considered as rather weak and flimsy. Example:—Rock Island Sheep's Wool—two the pound—Unbleached, SV(2U)AT1S.

seldom, if ever, used in current production, or at least infrequently used, specified as "Unclassified Stores." That is, they are such items as will rarely, if ever, be purchased on repetitive orders, including desks, chairs, special automobile fittings for sales orders, etc.

The most important items in automobile stores are recorded in ledgers, each item having its own sheet, but unclassified items are ordered on serial numbers from one ledger record. In the control of materials, another essential element introduced was the stock bin tag, designed so that each new receipt of material was at once recorded on a tag and sent with the material to its bin in the stock room. Each bin is plainly marked and its location recorded on the storeroom copy of the purchase order. It carries a bin balance tag, upon which the receipt and depletion of stock is immediately recorded. Receipt of material is entered in the Stores Ledgers only on presentation of an approved receiving ticket, which is accepted as indicative of stock on hand only when it has been passed upon by Inspectors of Material. That is, no debit to stores is made until after the material has been passed upon and pronounced satisfactory by the inspection division. Then stock on hand is a fact, with no uncertainty in respect to scrap or rejection. This inspection is done rapidly, and enables the receiving tickets to reach the ledger in time to allow payments to be made promptly on all cash discount invoices. This is particularly important in the case of those materials which require chemical analyses or special mechanical tests.

The Stores Ledgers and the entries thereon are so planned that an exact balance sheet is struck at each transaction and checked with the storeroom tags as they close out by the issue of material. As each tag

closes it is sent to the Stores Ledgers, where the detail issues shown by the stock bin are checked to the issue as reported from the stores issue sheets. Any discrepancy is immediately investigated and corrected. Something very desirable is obtained in this connection in that the stock man at the stock bin, although widely separated from the ledgers, has within his powers and responsibility the keeping of an exact balance of stock on hand to agree to the records on the books. Not only quantities are recorded on the ledgers, but also money values, regardless of varying prices on the same article. Each new quantity of parts received is added to those on hand, and each new value received as shown on the purchase order is added to the old value on hand; the new value divided by the new quantity gives the new price. If there be no change, and even if there should be, the new price is calculated for each receipt of material. The charges for parts shipped from stores to the shops take into consideration the purchase price and make possible an exact money value inventory at any time.

One feature of the stores plan is that every person has a clearly defined and specified duty and responsibility. A fault can be thus located with such exactness that there is no attempt made to pass the responsibility from one individual to another. There are few penalties, because each person understands thoroughly that his abilities, faults, and discrepancies cannot escape managerial observation. A most important feature is the provision for each individual, unaided, to check his own accomplishment perpetually. By this arrangement, and the natural personal desire of men to do your work if they know how and can, very little discipline is called for.

When a change in purchase methods was requested from the Purchasing Agent, and he was told of the importance to Stores of exact purchase prices on purchase orders, the contention was made that this would not do, that the "trade" would not stand for publishing prices; furthermore, that it was most difficult to predetermine just what was to be paid for an article, and would cause considerable delay in placing an order. It was finally conclusively proven that there was such a delay, but it was also shown to be caused by the Purchasing Department's lack of touch with current prices, so a very large percentage of all purchase orders were placed by the Company without bargaining or prices. This fault could not be charged to the Purchasing Department only, but to the organization as a whole; that is, designs, drawings, schedules, and requisitions from the engineering and factory departments were received altogether too near the time for finish of product. In a later chapter I will give an extract from a communication of more recent date from our Purchasing Department, showing what improvements occurred to them by virtue of methods which were earlier opposed. One of the very helpful aids to the Purchasing Department has been the standardization of purchase times for different classes of materials—approximately 95 different kinds being on the list. The Purchasing Agent has agreed to a set time in which he will deliver into Stores each class of material after he receives a requisition. It is surprising that in the difficult year of 1916 little variation was evident in the practical results compared to standards. That is, if the Purchasing Agent agreed to accept 100 consecutive work days to bargain, buy, and deliver to Stores a special analysis steel forging, he almost invariably made good. Since

there is involved in this time, bargaining, buying, making, shipping, and receiving, any one of the elements can be modified in the case of special trouble, so that delivery can well be maintained within a specified time.

After the new methods of requisitioning, purchasing, receiving, storing, and issuing materials had been in effect for a short time, schedules began to improve rapidly as a result of the certainty of control of the fundamental element—material.

Such methods, with respect to materials, required that storerooms be put under very close supervision; that all of the individuals involved be trained to appreciate their new responsibilities. There were few changes in the stockroom forces, because such training proved to be entirely possible, even though sometimes trying to the older men.

With material provided to meet the product classification, the factory machinery and fixtures were then changed to standard position and interchangeability of feeds and speeds. Line shafts were cut apart and remotored. Machines were arranged to fit the combinations of operations and processes to better advantage. Mechanical motions of the machines were arranged, so that those doing common kinds of work would have the same feeds and speeds. The shops were generally overhauled. A larger stock of small tools and fixtures were obtained, and a tool storage department provided for their better care. The path for production of each part was determined and standardized; *i.e.*, the routing of the part through the factory was established. The routing was *not*, as usually the case, *to a department* where the foreman would choose his method, but rather *to the specific machine*, or group of machines. For routing of product, departmental lines were ignored.

If any work could not, temporarily, be accomplished by a machine on the standard routing, it would be placed on another similar machine by the supervisor of the department, or be referred to the routing department for a new placement. As mentioned above, machines were arranged in gangs as fast as they could be changed to exact mechanical agreement; so that if an operation was due on one machine, temporarily deranged, it could be placed by the despatch clerk at once on another machine with the same feeds and speeds. Such interchange provides variety of work for each workman, breaks the monotony of a day, and should be of real training value to him.

It is interesting to note, in connection with this point, that in a great majority of cases the workmen dislike the variety feature, and have placed themselves on record that they had much rather work on one operation throughout a day or longer than to have frequent changes with a complexity of machine preparation, change of material, machine, and drawing. Unquestionably, they desire to specialize. The great growth in mechanical industries has precluded the corresponding development of variety mechanics. So a large majority of workmen in shops now can operate but one or two kinds of machines. If, however, the product is of such limited quantity that there must be a considerable number of operations to each machine, it is obvious that the worker must change frequently. According to the theories of some, that is what the man should do, and for his welfare he should do many things. I was naturally interested to learn that a very much less frequent change would be entirely agreeable.

As each part is apportioned to each machine, the

time of that machine for each operation is determined as correctly as possible, either by exact time study or estimated from previous data. A machine burden book is opened to record such data for each machine. A machine capacity to be provided would then equal the total of this time multiplied by the number of cars to be produced in one day. This, divided by the work time in a day, forms the number of machines required. In this same machine burden book is recorded the kind and value of all repairs to the machine as a guide to the determination of the machine depreciation and the date at which the machine should be replaced by a new one.

The responsibility of selecting the machine for a given operation, routing the material and work to it, designing and building all necessary tools, jigs, fixtures, drawing up specifications for form and size of materials, etc., rests with the Tool and Operation Department. The workman does not commence his work until the machine has been prepared, the materials routed thereto and the tools and fixtures delivered on an operation tool list from the tool room. That is, the workman is supplied with material and tools *before* the job is assigned to him. This is fundamental. His job order is not issued until he and his machine are ready to commence production.

Control of all operations is thus centered about the "despatch room," from which all shop orders, tool lists, routing instructions, etc., are issued, irrespective of whence they may emanate. In this despatch room, the general clearing house for all shop communications, are a series of compartments, each containing a complement of partitioned boxes, or racks, which stand for the various types of machines in the shop under the

control of the particular compartment. Each one of the boxes, in the various sections of which are kept the shop cards, etc., represents one type of machine and carries that particular machine symbol. The shop cards, with attached inspection coupon made out by the Planning Department in accordance with the established schedule of production when received at the despatch room, are distributed to the particular machine boxes representing the machines on which the work is to be done and filed in order of date in the central sections.

When a job is commenced, a ticket is despatched to the "move man" instructing him to transport the material to the machine to be used, and a tool list is issued for delivery to the machine of the required tools, etc. When these have been received at the machine, the scheduled job order is withdrawn from its place in the central section of the machine box, both job order and inspection coupon time stamped and the two parts separated. The job order with a card of detailed instructions is sent to the workman, who then commences his job, while the stamped inspection coupon is placed in a forward section of the machine box. When the workman completes his current job, he sends his job order card back to the despatch room, where it and its inspection coupon, which has reposed in the forward section of the particular machine box, are immediately time stamped again and a ticket issued to the "move man" to transfer the material to the machine for the next operation. The inspection coupon of the completed job is placed in the inspector's rack for inspection and a time stamped new job card with detailed instructions issued to the workman, who then takes up the new job, the preliminary steps of having tools and

materials ready at the machine having been previously attended to. The old job when inspected is recorded and the job order time card despatched to the Paymaster's Department for payroll account. This procedure continues throughout the production period of the part, *i.e.*, as long as the particular part remains in the shop. Every other part and assembly is handled in a similar manner. Such, briefly, is the method of control of the Production Department.

Two important things are here shown: First, the foreman is a factor in the route of the work and is called into consultation at the time of routing to assist in making a standard determination. Once the determination is made, he must abide by it and be released from the clerical work. Once this standard route is established, he is relieved of repetitive effort with regard to the best man or machine for a certain piece of work. His technical knowledge of routing having been recorded at the time of routing, his undivided attention can be given to the direction of the work in process. This is equally true of tools, with respect to which the foreman was consulted. But once a given method is agreed upon, it cannot be changed until all parties to the original agreement have again collectively acted. This obtains a large proportion of best methods. Second, if there is a wide variety of work in process in a shop, there may be a very large number of individual jobs at any given machine.

One of the most difficult problems in a complex product made repetitively is to determine the exact order in which the jobs should be given out to the workmen. This problem was one of the most difficult which we have so far solved in our Scientific Management work. It was finally consummated in the development and

use of what are called "control boards." These and other material aids in enforcing the system of control will be taken up in the following chapters.

Chapter V

THE SCHEDULE, CONTROL BOARDS AND PNEUMATIC DESPATCH TUBES

OUR plan of manufacture is for *stock*, as must be that of any industry producing an article subject more or less to a seasonable demand, but at the same time manufacture is conducted on a definite predetermined schedule. This schedule is specified by the general management and has to be governed by the probable demands of the market, gained through previous experience and logical deductions. Therefore, output must be planned according to a predetermined schedule based in no small part upon anticipated demand. This necessitates a production schedule which can be readily speeded up or retarded, as the occasion may arise.

The management decides first upon the number of cars which should be built to meet the expected demand for the season and then arranges a schedule of production so as to supply the demand as efficiently as can be foreseen. It is evident that should work on the entire season's contemplated output of cars be started simultaneously and progress maintained constant all cars would be completed at, or about, the same date. This would be suicidal to efficient production, for it would entail an activity far in excess of the capacity of the plant, followed by a long period of idleness. Furthermore, the demand is not usually as great

early in the season as subsequently, when the model has become better known and has created its market. And again, the demand should be stimulated if the model has been a success. It is also probable that the demand will decrease toward the end of the season. Of course, production cannot exactly follow the rise and fall of the market, but it can best meet the demand by an accelerating schedule of production. The acceleration should commence with the start of production in order to assure a solid foundation for the support of succeeding activity. It can always be retarded should the occasion arise; for instance, in the event of a poor market or unpopular model.

Our experience has been that the time from the requisition of the material for the first part worked upon in the construction of the car until the car is completed and delivered to stores for the selling department of the organization will cover a period of some one hundred and seventy working days, if cost of production is maintained within reasonable limits.

The desirable schedule of production, the accelerating schedule, may be depicted by a rising production curve, uniform increments along which measure the number of cars to be constructed (see Figure 8). The base line (horizontal projection) of the curve may then be considered as measuring the period over which the cars represented by the curve are to be completed, so that the projection of any point on the curve, indicated a specific number of cars, on the base line fixes the date at which such number of cars is to be completed.

In an industry in which a large number of cars is to be produced each season, such as ours, it is advisable to divide the total number of cars to be produced into

a number of "lots" scheduled for specific dates and to plan for lot production rather than to attempt to plan construction for individual cars or for the entire season's output at one time. For convenience, it is also

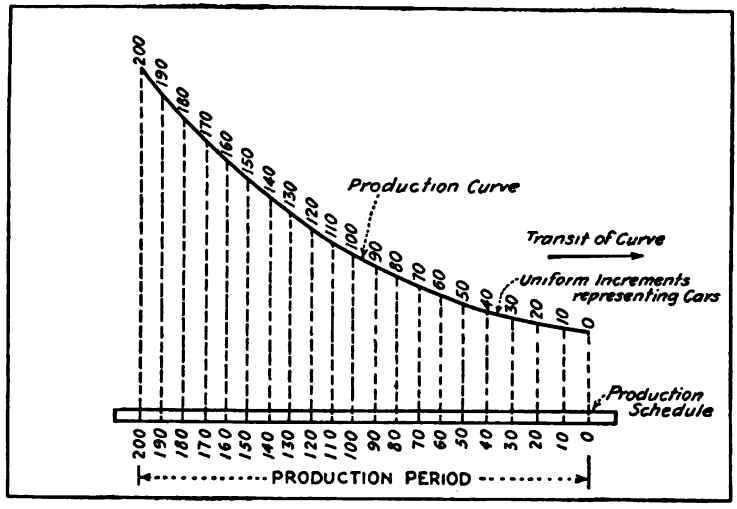


FIG. 8. ACCELERATING PRODUCTION SCHEDULE

advisable to have the lots of uniform size. Obviously, the production of each lot must be according to the adopted production schedule, so that the horizontal projection of any point on the lot production curve on the base line will indicate the proportion of that lot which must be completed on a specific date.

As the production of both the season's output of cars and that of each individual lot is based on a definite schedule, the production of all individual component parts and assemblies must likewise be according to the same rate of progress. An accelerating production of cars necessitates a similarly accelerating production of all the individual parts entering into the completed car.

The issuance of the necessary shop orders for the numerous acts required in the preparation of the various parts and assemblies entering into a complex product, such as we build, in strict accordance with such a schedule of manufacture, would entail, under any ordinary method of control, a stupendous amount of work and the liability of much confusion. To simplify the task as much as possible, we have developed our system of Control Boards. These act as mediums to guide the carrying on of all necessary acts in the preparation of our product, so there may be a minimum of confusion and a maximum conservation of capital in material in stores, and of material and labor costs in "work in process."

The Control Boards, a general view of which was shown as Figure 5, Chapter III, are some ten feet in length, and carry a continuous vertical curtain of horizontal flat steel tubes, with extruded aluminum slides one-half inch in width extending the full width of the board. These tubes are hung on vertical cables passing over drums on a double line-shaft in the crown of each board. The slides are retained by guides fastened to the tubes in such a way that the cables will slide freely through each combined strip, of which there are a sufficient number to cover at least three-quarters of the height of the board—approximately six feet. Through suitable mechanism, this curtain of combined strips may be opened up to allow the insertion of additional strips, or strips may be removed and the curtain again closed. The combined strips as they hang on the cables are spaced one-eighth inch apart, and, except at the time of changing the strips, the curtains are held firmly against the frame of the board by end guards.

At the upper corners of each Control Board a differ-

ential reel is attached, with a ribbon guide connecting the pair. These are to accommodate the "schedule tape," which governs all the acts for which the Control Board serves as guiding medium. This schedule tape, proportioned so that each half inch represents one work-day, is a duplication of the production schedule, as obtained by the projection of successive, equally spaced points on the lot production curve upon its base line (see Figure 8). On a schedule tape, the values read from right to left, and such a tape is prepared for each lot of cars manufactured. In addition to this governing, or controlling, tape, two other measuring tapes are required for the set-up of the board and as conveniences in making work-day measurements. These tapes, a work-day measuring tape, also reading from right to left in consecutive half-inch work-day units, and a work-day calendar tape similarly proportioned, but reading from left to right, are carried on a type of balanced straight-edge, which can be raised and lowered in front of the Control Board display curtain. At the ends of this straight-edge sets of reels and connecting guide are carried for the support of the work-day measuring tape and of the work-day calendar tape.

The equipment of the boards consists of four principal items:

First: Vanadium steel cages, one-half inch square, so designed and made that they will clip tightly to any strip anywhere on any board. That is, the strip widths and the steel cage construction is sufficiently perfect to be exactly interchangeable, and to clip the strip with sufficient force so that the cage cannot be readily removed.

Second: Boxwood type with printed celluloid number

faces cemented thereon, gauged so exactly that three will fit snugly into the springs in the steel cages. They will not fall out under ordinary use, but can be readily removed without detaching the cage from the strip. And other boxwood blocks with plain celluloid faces, for various purposes—all designed to be interchangeable in sets.

Third: Specially designed parallel jaw pliers for setting or removing the type in the cages.

Fourth: Monroe Calculating Machine, which is exceedingly flexible, for frequent combinations of addition, subtraction, multiplication and division.

We have at present twelve control boards with twenty-four control curtains, approximately 2,500 combined strips; 15,000 steel cages; and 50,000 type and marker blocks. All strips, cages, and type are machine made and can be considered strictly interchangeable. The pliers will not slip from the type. The type, in combinations of three, will not fall from the cages, but can be drawn with the pliers without dislodging the cage from the strip.

The boards were designed by the writer and his staff, and were constructed in our works.

The primary idea in this mechanism is that of a universal bulletin board, on which any information can be placed in any relation. If desired, co-ordinate relations can be shown through the mechanism.

We have provided one combined strip for each motor car part which we manufacture. We do not use a strip for any part that we purchase finished, ready for assembly. There are a sufficient number of steel cages, so that one is available for each operation which is to be controlled—as patterns ordered—requisitions for purchase order, stored material, issue of material, ma-

FIG. 9. DETAIL OF CONTROL BOARD

chining to be done at each station, and stored parts in finished stock. The cages are erected on the strips according to the order of action and standards of time. At the right-hand end of each control board is an index mark (zero) which represents the position of the finished car. Each half inch to the left of this position is considered as one work day. With boards ten feet long, it is evidently possible to provide for 240 work days, the time limit for the production of a lot. The name and lot-size markers are erected on the strips at the right of the operations.

The cages for the different operations for the different parts are put on their respective strips as many half-inch, work-day spaces to the left of the zero point as the lot must be started; thus the lot can pass through its succeeding operations to finished stock, and then be issued in proper quantities to assemblies in time to be contained in the finished car.

To illustrate: In the classification chart (Figure 1, Chapter III) the clutch drum, drawing number 17848,* is shown as a particular part in the clutch assembly. This was detailed in the chart (Figure 4). After passing the operations shown, and the lot of clutch drums has reached the finished stock, they must be issued in assembly quantity with other parts to the assembly floor to produce a lot of assembled clutches. The clutch must then be assembled to the engine, the engine tested and assembled to the chassis, the chassis tested and assembled to the finished car, and the car tested and inspected before being accepted as finished at the index point. In the same chart (Figure 4) on No. 3 Punch Press, Operation No. 4 (3PP4), work must be completed a considerable number of work days before

* Drawing number has been changed to 21405 in last model car.

the completion of the finished car in which this part will be used. This number of work days plus the sum of the number of work days required, or allotted, for the last operation (Operation No. 4) and the time allotted for the worked material inspection, which occurs immediately upon the completion of the last piece of the lot on the final operation, establishes the distance of the last operation cage to the left of the zero point. The cage for the operation immediately preceding the last operation is then mounted as many half-inch spaces to the left as there are work days allotted to the next to the last operation, per lot. The other operation cages, the cage requisitioning material, etc., are similarly located on the strip for the clutch drum.

The information provided for the erection of the cages on the strips is, part name, drawing number, symbol, standard size of lot in which parts move from one operation to the next, standard time to be in the finished stock (this has been accepted as four days), and standard allowance time of one day for each operation in addition to the actual producing. This provides for time to move between machines and for interferences at machines; standard stores time in which the part will remain in the storeroom after it has been received (10 days); and standard purchase time representing the number of work days from the requisition in the hands of the Purchasing Agent until the time he delivers the material into stores.

With these standards established and recorded, the erecting clerk can erect each part on its respective strip, clipping a cage for each operation, as many half inches from the car index point as there will be work days required to reach it. He then places markers in

the lower part of each cage to show the symbol of the station and the number of the operation there to be performed. Once the Control Boards are erected and all cages placed they are not changed, except as standards mentioned above are changed. Usually, on account of the extreme care taken in the department of standards, a large percentage of the erection will stand throughout the life of any given design.

The movable feature, to provide for changing schedules, is the schedule tape at the top of the board, the calendar tape on the straight edge, and the boxwood type in the cages. The schedule tape progresses half an inch to the *right* each work day, and indicates at each cage what orders must be issued to the stock and despatch rooms. As each operation job card is called out by the schedule tape, an order clerk enters on the job card the day due on the machines. As job cards are posted in despatch room boxes, they are arranged in order of date. This provides explicit instructions for order in which to issue jobs to workmen.

If, for any reason, this order cannot be maintained on account of material being spoiled or special fixture on previous operation broken or missing, the date is not changed or the card removed, but it is marked with the holding clause. When again available, it assumes its place in the line of Control Board dating. The figures posted in a cage are sum totals of *cars* which have been satisfied by the particular operation since the beginning of some definite schedule, as reported through the despatch room. After such posting, the quantity is readily referred to its corresponding quantity called for on the schedule tape above. If the number on the schedule tape is to the right of a vertical line above the cage, the operation is behind schedule;

if the corresponding number on the tape is to the left of the cage, the operation is ahead of schedule. If a vertical line be dropped from the number on the tape, the distance measured in one-half inches from this vertical line to the cage will indicate the number of working days ahead or behind schedule.

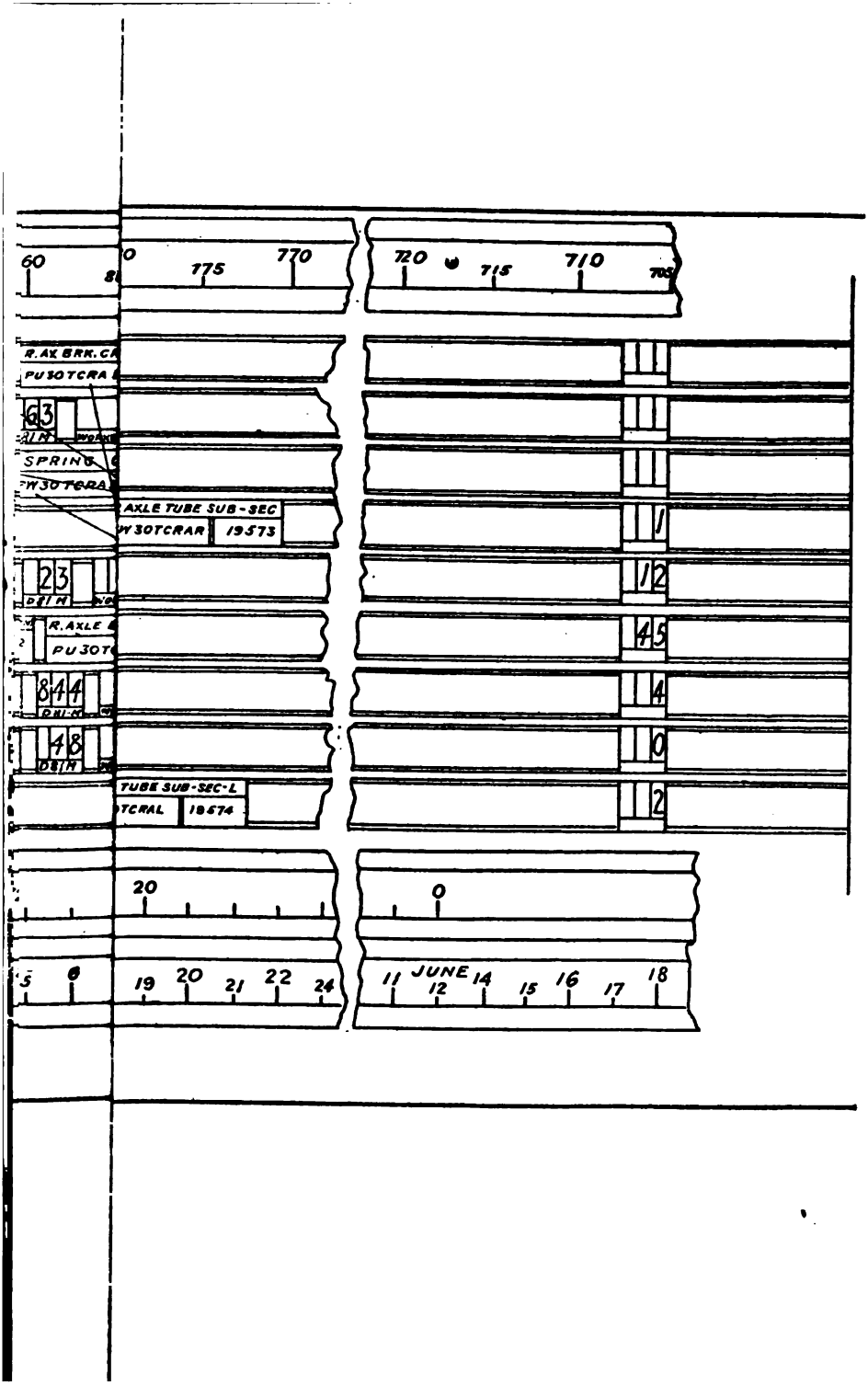
This ready comparison of completed work, as posted in the cages on the Control Boards, with the scheduled output, as called for by the schedule tape, can be made for any and all operations on each part or assembly worked upon, for the various operations are mounted on their respective strips only at predetermined fixed locations. The progress on a part needed a considerable time in advance of car assembly and shown mounted, therefore, toward the left of the Control Board will be displayed as ahead of progress on a part needed at some later date and caged further to the right of the board, for instance. The locations of all cages, the set-up of the Control Boards, are determined from the times required for specific operations and the number of work days, prior to the completion of the car, at which the particular part is scheduled into finished stores for subsequent requisition to assembly.

The locations of the cages on the Control Boards are permanent, unless—as occurs but seldom—changes are made in design, methods or operations, quite irrespective of the lot or schedule. That is, once a Control Board has been set up, it is not altered in any way for a change in schedule. This point is well brought out on the detail of a Control Board shown in Figure 10, where one schedule is pictured expiring at 860 and another commencing. The accomplishments as posted in the various cages refer to progress in

work on the schedule for which the schedule tape above the particular operation cages is operative—those toward the left of the board mark progress on the new schedule, while those toward the right refer to work on the schedule nearing completion.

The permanency of the Control Board set-up is obviously one of its desirable features, but occasions may arise when it becomes advisable to advance production or to delay activity on some particular part, or parts. In such events, all that is necessary is to move the set-up strip allotted to the part affected a certain distance to the left or to the right—to the left for an earlier start, and to the right for a later commencement of work. The location of the cages on the strip is not altered, the strip simply moved horizontally across the board. If the movement is toward the left, it means that the various operations will be called out by the schedule tape somewhat earlier than would otherwise have been the case and within a certain period the completion of such part will regularly occur as many days in advance of the previous date of completion as there are half-inch spaces through which the strip is shifted. Movement of the strip to the right will have the opposite effect, resulting in the completed parts being turned into stores so many days later.

Should several lots of different parts happen to be waiting at some machine to pass, any uncertainty as to which lot has the right of way is removed by the action of the despatch room under instructions arranged in the correct order by the Control Boards. *Since each of the orders fundamentally is directed by the single schedule tape, and since the schedule tape is but the schedule of the finished product applied to each*


60
775
770
720
715
710
R.AX BRK.CA
PU30TCRA
SPRING
PW30TCRA
AXLE TUBE SUB-SEC
PW30TCRAR
19573
63
23
R.AXLE
PU30T
8414
4810
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operation to cause it to be started in its proper time and sequence, it is evident that the determination of a finished car sales schedule provides an order of work directing all animate and inanimate forces in the manufactory.

Records of the exact condition of manufacture are obtained by photographing each Control Board face once each week. In proportion to the productive output, the clerical organization is materially less than under an older form of detailed records on route sheets and assembly charts. However, old data are readily accessible, and, having been photographed, are evidently exactly as they appeared at the time.

The Control Boards have been a true economy both in the financial conduct of the office work and in the elimination of misapplied effort in the factory. They have not added to the confusion of management, but instead have so clearly mapped out the exact procedure in a semi-automatic manner that fully 80 per cent. of the activities are carried out according to the ideals of the management without confusion or inquiries during the life of the schedule, usually at least six months. They record the acts emanating from the Planning Department, the management, and also the attainments realized in the shops. Every move of the management is directed and every accomplishment of the workers recorded. This necessitates a clearing house for the distribution of orders, etc., the despatch room mentioned in Chapter IV.

Our plant, like the majority of establishments which have been built up and expanded to care for a growing business, comprises a group of buildings more or less contiguous and several stories in height. The connections between buildings are planned primarily for effi-

cient routing of work through the plant, and various buildings house different departments. Each one of these departments must be connected with the Control Boards for the receipt and despatch of shop communications, etc., likewise the various tool rooms. A despatch room for each department where the workers could hand in their completed job cards, etc., and receive new instructions (our former arrangement) involved many miles of messenger service each day, with an accompanying loss of much time, creation of confusion and liability of disturbance in the priority of instructions. These decided disadvantages have been overcome and certain other gains realized by substituting for the various small individual despatch rooms one large main clearing house connected with the various shop departments with pneumatic tubes for the transmission of all communications. This large despatch room is located in the building housing the Control Boards, adjacent to them and also to the Planning Department.

Under the former arrangement of individual despatch rooms, when a worker finished a job and desired a new one, he would be apt to find other workers at the despatching cage so that he would have to wait his turn in handing in the old and getting the new job ticket. Often a man would start an argument over the job he was given or the job which he thought he should have. The clerk in the cage would sometimes be blamed and at any rate all the men waiting would be delayed and the production of all of them unnecessarily held up.

Under the new arrangement of centralized despatch room there may readily be more terminals in the shops than there were department cages in the despatch room. All the worker needs to do on finishing a job

is to insert the card in the pneumatic tube carrier, wait a short time and a new job ticket reaches him through the tube. Although there are approximately 1,500 jobs despatched in a day, there is practically no delay in getting the new job ticket to the waiting workman.

The centralization of the machinery of putting work through the factory makes for a quick adjustment of any difficulties which the worker may have with regard to machine or tool breakage, slowness of machine with resulting loss of premium, working on jobs out of their regular date order, etc. Also it has eliminated, as stated, personal contact between the workers and the despatching clerks and thus unnecessary conversation is a thing of the past. The result is a more rapid handling of the jobs and a greater degree of harmony between management and men because of the rapidity and ease of adjusting difficulties, for which often the clerk in the cage was unjustly blamed. Now, the worker waiting at the tube terminal knows there is nothing personal about his designation to a given job and that if the lot of material is not at his machine or the machine is inoperative, the difficulty is easily taken care of by action of the proper persons in the Planning Department.

The system comprises 3,500 ft. of tubes in 25 lines, three of them 3 in. in diameter and the remainder 2¼ in. The system is operated by compressed air, an electrically driven compressor with a 35-hp. motor being provided. The carriers are of leather slightly less in diameter than the tubes and each is fitted with a felt washer at the bottom large enough to fit the tube snugly and act as a gasket or piston against which the air pressure acts.

At the central despatching point, or pneumatic tube desk, is a row of pegs, one row for each tube. When a carrier has been emptied it is inverted on one of the pegs. It remains there the short interval required to get the new job ticket before being returned to the tube. The number of inverted carriers thus indicates the number of men waiting at a terminal. If three carriers, for example, are found inverted at one tube, it follows that there are three men waiting for new tickets at the terminal. The work of the despatching room is done so rapidly, however, that seldom are there as many as three men waiting for jobs in the same department.

Chapter VI

EMPLOYMENT AND RATE FIXING

DOCTOR TAYLOR'S principles of Scientific Management stipulate: First, the development of the science and, second, the selection and training of the workmen to conduct efficiently their share in the co-operative activity developed under such management. The science is not completely developed with the introduction of the control, the assumption of the management of its logical and proper responsibilities and the efficient interchange of instructions and reports, as discussed in preceding chapters; but, further, equitable rates and recompense must be established. This is part of the development of the science, and, at the same time, is the resultant consideration upon which the selection (classification) of the workmen must depend, as well as the incentive making for their intensive training.

When the mutual advantage of hearty cooperation is once grasped, as it tends to be during the sane and careful development of the science, the workman is naturally attracted to the work he is best fitted to perform, and the very human desire to secure a high rate of pay causes him to strive for a higher rank in his class and to acquire the necessary skill which demands and assures promotion. Thus the second principle is closely dependent upon the first, and it is in fact diffi-

cult to differentiate between them in an actual application of Doctor Taylor's principles to the management of a present day industry. In fact, the impossibility to demark strictly in the practical application of these fundamental principles emphasizes their basic and inseparable co-relationship.

Selection is largely a matter of employing the right man for the right place and it should be freed from any taint of favoritism. In an organization composed of a considerable number of departments (as is ours) this can be best secured by concentrating the authority of employment and discharge in one person who is directly responsible to the management. This concentration of authority eliminates as far as possible the evils arising from the entrance of the personal equation into the employment problem, and that this personal equation should most certainly be eliminated is evidenced by the fact that the promotion and demotion of workers in a very large part of our industrial population is based on about 20 per cent. efficiency and 80 per cent. personal relationship.

In our system, an Employment Manager has the sole right to employ or discharge men, but no one is employed who is not also satisfactory to the Supervisor, or Foreman, of the department in which he is to work. And, while the Supervisor cannot discharge a man without the approval of the Employment Manager, he has the right temporarily to suspend any man against whom he has a charge until the case at issue has been investigated, or any man for whom there may be insufficient work. If the worker cares to appeal and if his contention is sustained, yet it does not seem desirable, on account of personal relations, to return him to the department from which he was removed, nothing should

preclude his being transferred to another department.

One of the first steps we took in relation to the employment problem was the issuance of the following order:

"To All Foremen and Despatch Clerks

Subject:—discharges and disciplinary measures

Workmen *whose records show* that they cannot do the work satisfactorily in the department in which they are located may, after proper consideration by their Foreman, be released from that department, but not from the employ of the Company.

The Employees Record Card (Form A-210) must be filled out by the Foreman and sent to the Employment Superintendent for investigation. The Time Office will recognize only those payment cards signed by the Employment Superintendent and endorsed by the writer.

When a workman violates the Company's rule, he must be sent to the Employment Superintendent and the complete facts reported at once to the latter by the Foreman.

Payment and Record Cards (Form A-36) will hereafter be made out by the Employment Superintendent only after the workman's case is investigated and the circumstances warrant discharging him.

Foremen only have departmental disciplinary authority. The Employment Superintendent shall act on the merits of each case in a fair and impartial manner."

This created a court of appeal which, when fully understood and properly used by the workmen, satisfactorily solved one of the most trying and bitter problems affecting the employment of labor. Its object is equity

and fairness, both to the organization and to the workmen. In order that the Supervisor may not abuse his authority of suspension, it is necessary that the workman appreciate in full his right of appeal. Occasional instances did occur in our plant during the development of our system of management where men were unjustly suspended for indefinite periods. Such unjust suspensions were invariably due to personal prejudice on the part of the foremen, a failing which is unfortunately human, but nearly always antagonistic to the best interests of the organization, and one which must not be allowed scope under Scientific Management. The remedy lies in the right to appeal, and when the men realize that this appeal is not only their right, but their duty, unwarranted suspensions are much less likely to occur. Such has been our experience, and it is deserving of note by every management and all workmen. We invite the investigation of all grievances, and justice must result under a system of management in which all work to a common end, with the same fundamental interests.

Justice must be the cornerstone for fair and satisfied employment, and likewise must be the basis for fair and equitable recompense, both to management and to workmen. This is the groundwork of Scientific Management as we see and practice it—an equitable division of work, just treatment and fair recompense. The men are virtually set up in business for themselves and must give their best, both for their own interest and that of the organization. Fundamentally it directs first towards individualism and then to group action which will finally culminate, when completed, to concerted action for all classes, and trades towards common interests—in no sense antagonistic to

the welfare of the management. It provides for a gradual movement from the lowest worker through the master workman and foreman into managerial staff positions. *There is no sharp line of demarkation between the worker and the management.* It not only does not lead to profit sharing, but provides the full profits of the work-lines. This not only provides for the full profit of the managerial effort returns to the management, but it tends to stimulate personal development through assistance given in the learning of new trades and processes by the worker, and by monetary recognition when such increased knowledge is attained; it provides a monetary value for years of service; it provides for a definite retainer, if, for any reason, the worker is suspended from task work upon which he could make extra earnings for extra effort, and is caused to work on straight hourly time, *the retainer is proportional to his effort when under task.* From these extra allowances, which are normally much above a prevailing rate, are deducted amounts to cover losses due to lates and absences and spoiled work.

As interpreted by us, the application of such equitable co-operative activity follows: The assumption is carried out that the management will provide space, heat, light, sanitation, service, machine, tools, and methods to the worker; that after the management has established a time cost for the part, any effort of the worker which tends to reduce the cost will be recognized *by the full payment to him of any saving.* The saving in cost includes not only the saving of his own time but also those fixed charges which his saving of time will save. If the investment placed within his hands is misused, or if he sees fit to close up shop, throwing the incidental burden thereof on the manage-

ment, when he again comes in the employ after an absence of a few hours, or not more than three days, he pays back the losses which have occurred, if he still desires to retain his position. This is, obviously, not paid back in a lump sum, but on the next wage rate adjustment (quarterly the base rate of pay for each workman is revised) the wage rate is reduced an amount which, during the three months period of its run, will compensate for such loss. The method indicates the aggregation of a number of small shops each manned by one worker receiving community service, in which investment responsibility when not in use falls upon the management, and in which the worker assumes the responsibilities which are naturally his if he assumes to operate that shop.

The establishment of an hourly rate of pay equitable for *all* concerned involves the consideration of a number of factors which must bear a definite and intimate relationship to one another. This may be conveniently expressed in the form of a general equation, or special formula. The general equation for the basic rate, where the premium method of payment is used, as deduced by us is

$$r=\left[\left(\frac{K[B\ (1+i+m+ny)+R]\ (1+2e)}{V\ (1+1.3E-.3e)\ (1+.35P_s)+S}\right)\left(P_t+P_d(1+.5e)\right)\right]C$$

and for the determination of labor and indirect cost (not including materials) is:

$$X=(r\ (1+e)+R)\ t$$

The definitions of terms follow. They are common in both equations:

r = Base hourly rate man is to receive
K = A constant, when V is 100 per cent., to bring

worker under standard conditions to standard rate

B = Fundamental base rate, temporarily that of 1905

i = Percentage of increase in living since 1905, taken on the 15th of January, April, July and October of each year

m = Percentage allowed for each extra process known or learned

n = Percentage allowed for years of connected service

y = Years of such service

R = Fixed charges rate per hour which man has chance to modify

e = Percentage of premium earned on time allowance

V = 100, which is the standard accomplishment per cent.

E = Standard premium task time set

P_a = Percentage of time absent or late

S = Value of spoiled work per producing hours worked

P_t = Percentage of time under task

P_d = Percentage of time spent on non-task or straight time work

C = Co-operation and conduct

X = Labor and fixed charge cost

t = Time taken to do work

NOTE: See Form I and I*a* for analytical statement.

CO-EFFICIENT (K).—Since in a factory of many processes, or in different factories, a very considerable difference in skill is required, there is consequently a varying base wage. To illustrate: A laborer may receive 20 cents per hour, and a skilled toolmaker 50 cents per hour. However, the fixed charge rate (R) may be very high or low depending on the investment value of

FORM A-1170 MFG

RECORD OF WORKMAN'S TIME AND EARNINGS

WORKMAN'S NUMBER 532

WORKMAN'S NAME

	19 WK ENDING MONTH	DAY	TIME WORKED IN HOURS A DAY WORK	B FROM WORK	C=A+B TOTAL HOURS	TOTAL T. MAN COULD HAVE WORKED	TIME LOST E=D-C	DATE LATE OR ABSENT	REASON FOR ABSENCE	PREM. HOURS EARND. HRS	U TO THS	CENTS AVERAGE EARNGS PER HR. F G=E/F	TOTAL WEEKLY EARNGS =F	CENTS RATE PER HOUR	F. H. B. A. ASSESSMENT	TOTAL PAY LESS ASSESSMENT	19 WK ENDING MONTH	DAY	TIME WORKED IN HOURS A DAY WORK	B FROM WORK	C=A+B TOTAL HOURS	TOTAL T. MAN COULD HAVE WORKED	TIME LOST E=D-C	DATE LATE OR ABSENT	REASON FOR ABSENCE	PREM. HOURS EARND. HRS	U TO THS	CENTS AVERAGE EARNGS PER HR. WORK G=E/F	TOTAL WEEKLY EARNGS =F	CENTS RATE PER HOUR	F. H. B. A. ASSESSMENT	TOTAL PAY LESS ASSESSMENT
1	1	8		50	50	50			1-15 A	29	.3	56.3	28 15				27	7	8		41	41	41				34	.2	90.7	37 22	49.5	Inc
2		15		45	45	50	5.			25	.5	55.6	25 03				28		15	29.0	35.4	65.3	80				10	.5	68.	44 45		
3		22		50	50	50				26		53.9	26 98				29		22	3.	53.6	56.6					37	.4	84.1	47 62		
4		29	1	50	51	50				30	.6	57	29 08				30		29		56	56					35	.6	83.6	46 83		
5	2	5		45	45	50	5.			32	.3	61	27 44				31	8	5		59	59					30	.2	84.9	50 09		
6		12		50	50	50				32	.5	65.5	29 39				32		12		59	59					35	.5	84.3	49 70		
7		19	2.9	48.9	51.8	50				31	.1	57.2	29 64				33		19		59.1	59.1					30	.0	84.7	50 00		
8		26	2.2	49.6	52	50				35	.7	60.7	31 56				34		26		59	59					54	.8	96.4	56 33		
9	3	4	10.1	48.4	58.5					27	.5	55.2	32 31				35	9	2		62	62					43	.2	87.	53 96		
10		11	3.6	49.7	53.3					31	.3	57	30 53				36		9	17.3	32.7	50	41				13	.4	71.6	35 84		
11		18	23.7	26.3	50					18	.4	48.5	24 28				37		16	35	51.5	55	46				48	.8	96.1	52 87		
12		25	14.3	38.8	52.6					25	.1	53.4	28 12				38		23		67.	67	50				49	.1	97.1	65.11	58.5	Inc
13	4	1	54		54					1	.3	37.2	20 10				39		30		67.	67					00	.0	105.6	70 94		
14		8	16.4	33.6	50					4	.6	39.5	19 74				40	10	7		56	56					11	.5	95	53 23		
15		15	49.2	.8	50							39.9	19 99				41		14		68.7	68.7					04	.2	106.1	74 31		
16		22	27.4	22.6	50					15	.6	47.9	23 98				42		21	3.9	46.1	50					43	.4	106.3	52 64		
17		29		50	50					2		37.6	18 82				43		28		50	50					44	.5	101.1	50 56		
18	5	6	6.5	47.2	53.7					34	.1	59	31 67				44	11	4		50	50					41	.4	99.8	49 89		
19		13	14.7	36.9	51.6					6	.5	48.8	25 20	43	Inc.		45		11		45	50					41	.5	97.9	48 95		
20		20	23.3	28.7	52					30	.6	69.1	35 95				46															
21		27	2.	49.6	51.6					15	.5	56.9	29 37				47															
22	6	3		36	36	41	5.			15	.3	61.3	22 06				48															
23		10	10.2	44.8	55	50				30	.6	68	37 41				49															
24		17	1.	49	50					15		55.9	27 95				50															
25		24		50	50					32	.1	70.6	35 30				51															
26	7	1		50	50					16	.3	57	28 51				52															

None Deducted Pay Monthly-25 Cts.

FIG. 11. FORM I. ANALYTICAL RECORD OF TIME AND EARNINGS OF WORKMAN NO. 532

WORKMAN'S RATING

CLOCK NO. 532

NAME

PERIOD	BEGINS			ENDS			HOURS IN	CUR. RENT RATE	INTO EFFECT			100	For Group	Base Rate	% Inc. Lv., Cont.	Ability Factor	Service Factor	TOTAL	Fixture Ex. Rate	% Set Task	% Task Earned	% Time on Task	% Time on Day	% Time Susp.	% Time Allowed	Aver. Spelled	Group Contract
TAKEN	MO.	DA.	YR.	MO.	DA.	YR.	PERIOD	r	MO.	DA.	YR.	V	K	B	1(+l	+ m	+ 97)=		R	Group Mgt. Av. a	$a = \frac{R}{V}$	$P_T = \frac{t}{h}$	$Pd = \frac{d}{h}$	$P_S = \frac{s}{h}$	$P_{AV} = \frac{a}{h}$	$S = \frac{Sl}{h}$	G
1	4	8	16	6	2	16	450	49¼	7	1	16	100	83	.25	(1+.5	+.20+	.23)	.6901	.59	82.3	42.7	.69	.31	—	2.2	—	1
2	6	3	16	8	26	16	996	53½	9	18	16	100	81	.25	(1+.5	+.20+	.26)	.6916	.64	82.3	60.	.94	.6	—	1.4	.028	1
3																											
4																											
AVERAGE OR TOTAL																											

SERVICE	BEGUN			ENDED			In Our Employ	Hours' in For	Constant		Service Factor	Day Work	Task Work	Total Hours	Task Hours Allowed	Time Lost	No. of Absences	Absences Lost in Hours	No. of Lates	Lates Lost in Hours	Total	Allowed Absence	Abs. Allowed Not Used = s	Sick Absences No. Days	Sick Absences Hours Lost	Hours Sup. posed
RECORD	MO.	DA.	YR.	MO.	DA.	YR.	YRS.	Period Taken	n =		V	(d + l)	= h	u	a_1 +	(n x 8=	a_2)+	(N x 1=	a_3)=	a_1 –	a_n	Allowed = s		MO.	DA.	L
1	12	18	05	6	2	16	10.416		.025		.26	130.5	80.5	444.9	180.9	5	1 x 5	5	0	0	10	0	10	—	—	0
2	6	3	16	8	26	16	10.666		.025		.26	44	662	606	98.1	5	1 x 5	5	0	0	10	—	10	—	—	0
3																										
4																										
AVERAGE OR TOTAL																										

ABILITY	MAJOR PROCESS	ALTER'ATE PROCESS	EXTRA PROCESS	Total Credit's	Con stant	Ability Factor	Drawing No. of Part Spoiled	Lot No. Spoiled In	No. of Oper Spoiled On	Unit Rate, Check m	Total Oper. n	Mins Taken For Piece	Ideal Min For Piece	Net Oper. Per. D_p $\frac{m}{c}$ +	Work mens Rate r	Prem. Paid on Part (1+o)	Piecem. Rep. Earn. + R	Pieces Taken Out Piece	No Pcs Spoiled	Total Value = S_1
RECORD	HOW ON	CAN DO	LEARNED	(N - 1)	c	= m														
1	E – 1= ½	A-½ E-½	Buff and	(6 ½-1)	.04	.23	22158	8#	14	$10.60	20	60	60	.50	.48	1.6	.51	1	1	1.71
2		B-1½ F-1	Polish-½																	
3		C-¾ G-½	(2+ 4)																	
4		Da 2+2(H	(5)																	
TOTAL=N																				

CONDUCT RECORD	1.00	Debits	– N	Credits	+ P =	Net=C
1	1.00		0		0	1.00
2	1.00		0		0	1.00
3						
4						

87

FIG. 12. FORM 1a. REVERSE OF FORM 1. ANALYSIS OF RATING OF WORKMAN NO. 532

equipment which the operator attends. At the standard rate point for workers operating exactly to standard, where the fundamental base rate and fixed charge rate are identical, the constant (K) and the rate (r) will be the same. As the fundamental base rate or fixed charge rate changes, (K) will change and consequently rate (r). (K) is first determined for a class by inserting the established standards in the equation and solving for (K). It is then used in each future determination for (r).

FUNDAMENTAL BASE RATE (B).—The fundamental base rates have been temporarily taken as the prevailing wage rate for men who worked by the hour without task in the year 1905 (See Appendix I, page 169). Careful study of a long period of years through our records showed relatively less turn-over of labor in that year than in any other for a very considerable time before or since.

Wage increases were relatively frequent and uniform for the years 1904-5-6. Altogether it seemed to have been a period when the working community was in good condition and workers were able to obtain satisfactory wage rates without difficulty. *No attempt has been made as yet to determine the correct wage rate for the workers or in any way to establish fundamental values for their efforts*, but this fact has been established, if the base wage rates of 1905 were then equitable, our base wage rates are now equitable. Then, workers received no premium or extra recompense. It was a period during which, however, it seems the workers received a fair and adequate wage for their industry. Since the base wage rate of today is the wage rate of 1905 with *full allowance for the increase in living cost* in this district, with an in-

crease for *years of continued service*, and with increase for *acquiring a knowledge of extra processes*, their base wage rate is now proportionally greater than in 1905. In addition to this base wage rate there has furthermore been added a premium rate for special effort in which the first-class worker can and does regularly earn from 33 to 40 per cent., and sometimes higher, as an additional wage. This means that the worker today receives, as an average, 30 per cent. more than he did in 1905, in addition to allowance for extra living expense, years of service, and acquired learning.

The base wage rates of 1905 in the trade classes which we employ are shown in Appendix I, page 169. It is my opinion that there is but one fundamental base rate and that is the rate which that worker should receive, who, by virtue of lack of training or mental development, is least productive. With this as a base all other trades and crafts can be raised to standard base wage rates as a percentage on this one fundamental base wage rate. The percentage of variation would be measured by the relative cost of training the untrained worker to qualify in any one of the various skilled trades.

There is at present a wide-spread effort for the development of young men and women into skilled trades, but so far very little has been done to train the matured man, and in fact very little encouragement is being given to him to put forth effort to such an end.

THE PERCENTAGE OF INCREASE IN LIVING COST (*i*).—To determine the *relative* cost of a day's living in the district surrounding our works in which a large proportion of our workers live, and to develop standards for comparison in succeeding years, a very thorough study of such conditions was made by the company. No

attempt was made to establish the amount that a worker should live on, but only to ascertain the increased cost of sufficient items so that, given reasonable figures or proportions by the workers, a percentage of variation between the living cost in 1905 and that in subsequent years could be obtained. In this study, food, clothing, fuel, and shelter were the principal items in which comparisons were sought. While the items of food or clothing as expressed in the menus or clothing lists did not seem to be well balanced in the different meals of the day or different seasons of the year, it was not attempted to cover all items that might possibly be considered, but only to adopt certain standard items about which there could be no question of obtaining local market rates on the same bases from year to year. The selections as to food, fuel, and clothing were finally determined after a very considerable number of conferences with workers. From the summary, the "Percentage of Increase" over 1905 (*i.e.*, since the time of the fundamental base rate) is used directly in the equation as the term (i). The summary of the research is recorded in Appendix I, page 173.

PERCENTAGE ALLOWANCE FOR PROCESSES (m).—The release and employment of workers are possibly about twice as frequent on account of limited knowledge as for wilful leaving or discharge. In any industry working on a complex product, temporary shortages of material or temporary hold-ups on any one operation for parts having a large number of operations may cause a suspension of work in the producing line. If the worker in that line is trained only for his particular act, practically nothing can be done but release him from service for an indefinite time. In the same shop

and possibly not more than two or three machines removed from where he was working is a machine with plenty of material waiting for it and with the worker absent for any one of a number of reasons. For this machine the foreman or employment representative is probably trying to engage a man who can do the work. Such an unbalance in productivity is practically constant, one class of work behind, and another class of work ahead.

There is no question but what the cost of employment, training of a man in organization methods, losses due to slow operation on machine, and spoiled work is considerably larger in a factory doing refined work than has so far been stated as a fact by persons who have given this subject detailed study. The cost of training a worker of mechanical ability on one process to do another successfully so as to be in readiness for such an emergency, and the additional cost of a reasonable addition to his rate to make it interesting and worth while for him to so learn, will not equal in two years the cost of once employing an unknown outside man. The periods in which such assistance would be required are of relatively short duration, and in the course of two years would probably necessitate the employment and laying off of a large number of men, were it not for the inside assistance we are enabled to secure by the training of men for more than one task.

We have for the time adopted a rate of 4 per cent. for each full process more than one that the worker has acquired or will learn to do; and furthermore we will furnish an instructor in any process to any worker who really desires to learn and we will pay the time of such instructor through the teaching period. The

worker accepted, after his attainment has been passed upon by the factory inspectors and the foreman, will receive his process rate allowance after he has worked any full period of three months at the process. Processes are sub-divided into divisions of one-half or one-quarter, and fractional credit is given. The list of standard processes at present in use are shown in Appendix I, page 170.

PERCENTAGE ALLOWANCE FOR EACH YEAR OF CONTINUED SERVICE (n).—For the loyalty which develops in employees who have been long in service; for the historical knowledge which they have; for the *esprit de corps* which comes through long periods of association of men; as well as for a reduction in the frequency of labor turn-over, 2½ per cent. of the base wage rate is allowed for each year of collected service. If a man wilfully leaves the employ of the Company when we wish to retain him, and he is again employed, he sacrifices the credit for years of service. However, when it becomes necessary to reduce the number of employees, and the men are removed from service by the Company, if they return within a year no change is made in the rating. If they return after an absence of one year or more, the years of absence only are deducted from the rating. While the employment charge cannot be escaped in such a case, practically no other costs are generated by such employment.

THE FIXED CHARGES RATE (R).—Workers operate under widely varying responsibilities. In workshop production, the hourly fixed charges of a sensitive drill of very small size is insignificant compared to a large stamping press, or milling machine, or planer. Space, heat, light, sanitation, machine interest and depreciation charges, and service provided for the worker and

his machine will vary from a fraction of a dollar to several dollars per hour in fixed charges. These charges are continuous true expenses, not affected by active operations within the space. One hour of idleness may mean a charge of from 50 cents to five dollars against the product, for which there is no return. If one worker operates a machine having fixed charges of one dollar per hour, and does a certain piece of work in one hour, the fixed charge per piece will be one dollar. If another operator performs the work in one-half the time, the fixed charge per piece will be one-half dollar. If the work be on a piece rate system and the rate is fifty cents per piece, the total piece cost in the first case of one hour will be $1.50, in the second case $1. In the first case the worker receives fifty cents per hour, in the second case $1 per hour. That is, when the worker received the least amount measured on the basis of comparative performance, the total cost was 50 per cent. more than when the worker received a double earning for doubled effort. Under such a plan, while in the second case the worker received double the amount for double the effort, the management likewise made a profit of fifty cents per piece. The important point is this, if the management was in entire accord, or had set or agreed to the rate of operation as specified in the first case, and the worker willingly and wilfully cut the time in two by personal thoughtful effort, then the worker should receive an additional amount over and above his wage rate saving equal to his saving of investment charges. It is obvious that this is an exaggerated case. There is little probability that the management with full intelligence and proper care would establish a rate as illustrated in the first case. However, in the major-

ity of cases after the management has established what it is satisfied is a fair, equitable rate, and if at such time the worker co-operated with the management to establish as fair a rate as he could, then it is only right to assume that the extra effort has been attained through extraordinary thought and care on the part of the worker, and he should receive the fruits of his efforts. Conversely, if after an equitable rate has been established, and the worker through negligence creates a high cost, then his base wage rate should be so adjusted that the management will not lose on account of his negligence. This should be equally true for any idleness or spoilage of equipment or materials on account of the carelessness or negligence of the worker.

It is evident that by this method, if the management expects reduction of costs beyond that for a set task, the provision of new methods, better equipment and machinery, reduction in investment charges, or increases in quantity of output is the way in which to secure it.

The worker is not "exploited" in any sense of the word. The way is always open for him to learn new processes; with continued years of service and with willingness and ability to assume larger responsibilities which in a tangible way means space with larger fixed charges. It is but a step from this to the "master workman," when he assumes the responsibility of a group, or to the foreman when he assumes the responsibility of a department. A comparative statement of cost and earnings of one of our crank-shaft grinders is shown at the end of the article. (See Appendix I, page 174). This brings out clearly the importance of the fixed charges rate.

PERCENTAGE OF PREMIUM EARNED (e).—For some

years previous to our adoption of the Taylor System, we had been operating under a premium system. This was conducted approximately as follows:

A department with a number of clerks was employed to record the actual time consumed by the worker on each operation. After such record had been maintained until the rate of effort approximated a constant value, a premium rate was set; this premium rate was made evident to the workman by a notice to him that for any time which he could save on that operation, as compared to his previous average performance, he would be paid at one-half the rate in addition to his regular rate. That is, if the worker had established a rate of 30 minutes for an operation, and he saved 10 minutes after the rate had been set, he would then receive pay for 35 minutes for each 30 minutes which he worked and rates proportional for any given time of saving. Under this plan it was evidently left entirely to the worker and to his own ingenuity and personal effort as to methods of saving time—the management in no sense contributing to the saving—and for such time as he saved he received one-half rate only. The management profited by one-half the labor cost and *all* the fixture cost for the time saved. With the advent of Scientific Management, the management at once assumed its full responsibility to establish methods and mechanisms, and by virtue of an exhaustive research to determine what was a fair time in which the work could be done. In general, at the time of such determination and research on account of fundamental time-study having been used, both the worker and time-study observer were practically eliminated from any major influence on the result.

Our time-study work has been directed by Dwight

V. Merrick, one of Mr. Taylor's personal associates, and Mr. Merrick is in frequent consultation with our time study organization. The main responsibilities and resultant rates depend upon men who have had a large amount of mechanical experience, or a considerable amount of mechanical experience with a rather complete technical education.

As described in Chapter III, a standardization of machine feeds for all equipment in the works was made, and mechanical movements and rate of movement were recorded, so that for any mechanical operation the machine time, the depth of cut, or the speed and feed are determined and specified, the handling time only being the irregular variable. Since the time study has been taken on a given operation for a very large number of parts, and each element of the study which requires more than 2/100 of a minute is recorded, the various elements are readily compared and variations in time taken on each element noted. Through a standard procedure, the base time required is determined. With the addition of average allowances for unexpected conditions not involved in the study, a final rate for the part is set, this rate being the number of minutes in which the work should be completed. As a means of providing recompense to the worker for his constant attainment of this rate, and to interest him in bringing to the attention of the management any feature which precludes his making the rate, additional allowance time of 60 per cent. is added to the flat work rate, and the final time allowance is published. Thereafter for any time which the worker saves on that allowance time, he is paid for one-half that time; but the management has knowledge on account of its pre-planning that the time taken

should be the definite base time and therefore, it is expected with slight variation that the worker will save one-half the 60 per cent. allowance time and will be paid for this one-half, or 30 per cent. in addition to his flat base rate. There is no particular reason why a flat hourly rate including the percentage for accomplishment should not be set. Our chief reason for continuing the present premium plan is that it has been a particular procedure at the works, and is especially adaptable for the present rating plan.

If, then, a record be kept of the percentage of premium time which the worker earns, a figure which is used in the compiling of pay-rolls and costs, it is relatively easy to reduce this to the approximate percentage of time saved by multiplying by two. While this is not mathematically correct, within the limits of the figures used it is sufficiently so. The rate of productive effort is thus seen to be one of the principal elements in the rating.

STANDARD PREMIUM TASK TIME (E).—This value is the percentage of premium which the worker should earn as against (e) the percentage of premium which he actually does earn. The simplifying of the equation has made it somewhat difficult to appreciate the relation of this term in the equation. In practice its influence is to recompense the management for time losses of fixed charges on account of the slowness of the worker.

PERCENTAGE OF TIME FOR ABSENCE OR LATENESS (P_a).—On a closely fitted schedule, in which the mechanical equipment is adjusted as nearly as possible to exact needs, yet with a minimum of fixed investment, any absence of the worker will, in general, cause a corresponding overtime effort by that worker, or by a worker

substituting for him. Since our overtime rates carry one-third allowance to the regular rate both on base rate and on premium earning rate, it is only equitable that any conduct of the worker which will cause the overtime work to be required should be adjusted by his rating. It has not been unusual to have a worker absent himself for a part of the hours during the day, and then work overtime for the sake of the extra overtime pay. (See Form II—Fig. 13.)

Correction for work spoiled (*S*).—The problem of spoiled work on either a work-day or task rate plan has been a most difficult one to handle. It is difficult to decide what should be done with a careless worker who, while working fast, possibly earning high premiums, will spoil a large amount of work, or for the straight hourly rate worker who, in our experience, spoils practically as much. It is certainly not equitable for such a man to receive as great a recompense as the man who is careful and has a small spoilage, and there has been but practically one redress, and that is discharge. If each operation on each piece that the worker does must be inspected, the overhead charges become very large. If inspection is less frequent, losses may occur and not be discovered until a very considerable time afterward. At any rate spoilage is so frequent, of such an amount, and almost invariably traced to carelessness, that the management cannot withdraw from the workman's pay at a later date at one time an amount sufficient to cover the loss. The cost of the product thereby suffers. Our wage rates are set for high performance without spoilage—not as prizes awarded for little spoilage.

The amount to deduct for spoiled work has been a question of considerable moment to every factory man-

ager; for many times the worker will not only spoil a great amount of valuable material, but all labor and fixed charges which have been accumulated on the part prior to the time of his beginning work. For fixed charges caused by his operation the worker is respon-

FORM A-1288

WORKMAN'S ABSENCE REPORT

NAME	H.N.K.								CLOCK NO. 532		
LEFT WORK	MO.	DAY	HOUR	WILL RETURN	MO.	DAY	HOUR	DID RETURN	MO.	DAY	HOUR
	6	2	5						6	5	7

EXPLANATION:—Absences or Lates are allowed:	CHECK
When causing NO OVERTIME WORK.	NO
When NO LOT URGENT TAGS ahead of Man.	NO
When Workman arranges with Foreman for Workman's Job to go on without delaying Production.	YES
REMARKS: Specify condition of work ahead of Man:—	•

Man is ahead of schedule on his work

SIGNED:— E.J. DEPT. FOREMAN

NOTED				ALLOWED				CHECKED WITH WORKMAN'S RECORD			
MO.	DAY	YR.	HOUR	MO.	DAY	YR.	HOUR	MO.	DAY	YR.	HOUR
6	3	16		6	5	16		6	5	16	
SIGNED G.H.C.				SIGNED H.				SIGNED C.E.W.			
D-5 M. CLERK				EMPLOY. SUP'V'R.				EMP. DEPT. CLERK			

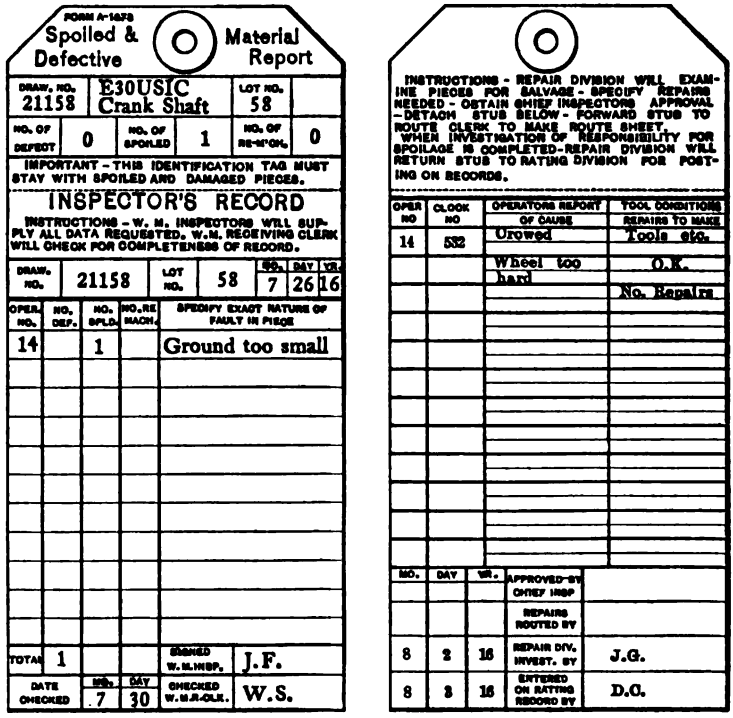
FIG. 13
FORM II. ABSENCE REPORT FOR WORKMAN NO. 532

sible and for the monies paid to him there is little doubt that he can be held accountable; but for the full material value or previous effort applied for which he is not accountable in any way, there is no justice in charging to him.

In our plan of rating, the worker recompenses, by a proportionate reduction in his base rate during the succeeding rate period, for such spoilage charges only as may be caused by his rate of pay and the fixed charge rate losses on his operation for which he is accountable—only, then, for that part which has been decided without question to have been his responsibility. No spoilage is charged until complete evidence has been obtained proving that the mechanical equipment, tools, or other factors over which he had no control were not a part of the causes. It is very unusual for such spoilage or loss to penalize a worker more than two per cent. per hour for his new rating period of three months; while at the same time he may be drawing 30 to 40 per cent. extra earnings for speed. The larger number of workmen cause losses so small that no penalty is attached. Altogether it has not so far seemed to have worked a particular hardship, but it has not as yet been tried out sufficiently to say that there is not some problem still left. If the spoiled work can in any way be redeemed, then the direct labor charges and fixed charges for such redemption only are charged to his rating. It should be clearly understood that fixed charges do not mean the conventional "overhead" rate, but such fixed charges only as the workman can influence. (See Form III.)

PERCENTAGE OF TIME UNDER TASK (P_t).—Under any task plan there are periods of work in which the worker is suspended from task, or work on parts on which no rate has been set. It is universal in any such methods of payment that such time shall be paid at flat base rate only. To determine the merits of this and to obtain a proportion of relative time of operation of workmen when under task or straight time, a

study was made of the time which workers used on parts on which task by time study was later set. The average result indicated that for a man accustomed to task work, if he saved a given amount on a part after



FORM A-1478

Spoiled & Defective — Material Report

DRAW. NO.			LOT NO.	
21158	E30USIC Crank Shaft		58	
NO. OF DEFECT	0	NO. OF SPOILED	1	NO. OF RE-M'CH. 0

IMPORTANT - THIS IDENTIFICATION TAG MUST STAY WITH SPOILED AND DAMAGED PIECES.

INSPECTOR'S RECORD

INSTRUCTIONS - W. M. INSPECTORS WILL SUPPLY ALL DATA REQUESTED. W.M. RECEIVING CLERK WILL CHECK FOR COMPLETENESS OF RECORD.

DRAW. NO.	21158	LOT NO.	58	MO. 7	DAY 26	YR. 16

OPER. NO.	NO. DEF.	NO. SPLD.	NO. RE MACH.	SPECIFY EXACT NATURE OF FAULT IN PIECE
14		1		Ground too small
TOTAL	1			SIGNED W. M. INSP. J.F.
DATE CHECKED	MO. 7	DAY 30		CHECKED W.M.R.CLK. W.S.

INSTRUCTIONS - REPAIR DIVISION WILL EXAMINE PIECES FOR SALVAGE - SPECIFY REPAIRS NEEDED - OBTAIN CHIEF INSPECTORS APPROVAL - DETACH STUB BELOW - FORWARD STUB TO ROUTE CLERK TO MAKE ROUTE SHEET. WHEN INVESTIGATION OF RESPONSIBILITY FOR SPOILAGE IS COMPLETED - REPAIR DIVISION WILL RETURN STUB TO RATING DIVISION FOR POSTING ON RECORDS.

OPER NO	CLOCK NO	OPERATORS REPORT OF CAUSE	TOOL CONDITIONS REPAIRS TO MAKE
14	532	Crowed	Tools etc.
		Wheel too hard	O.K.
			No. Repairs

MO.	DAY	YR.		
			APPROVED BY CHIEF INSP	
			REPAIRS ROUTED BY	
8	2	16	REPAIR DIV. INVEST. BY	J.G.
8	3	16	ENTERED ON RATING RECORD BY	D.C.

FIG. 14

FORM III. FRONT AND REVERSE OF INSPESTOR'S REPORT OF SPOILED AND DEFECTIVE MATERIAL FOR WORKMAN NO. 532

task was set, he would have approximately one-half of this time before the task was set. While this was not in any sense regular, nevertheless it was so common as to furnish a proportion for the setting of extra recompense in addition to base rate when not under

task. That is, if a worker earns 30 per cent. premium on a base rate of 30 cents per hour and receives a total earning of 40 cents, he receives 35 cents per hour when suspended from task. If on a 30 cent rate he earns 50 per cent. premium with a total of 45 cents

RETURNED FORM A-1277 MFG. ISSUED	Nov. 4, 1916 4:00 P.M.	MAN'S NO.	D 5 M 32
	Nov. 3, 1916 3:30 P.M.	NAME	H.N.K.

IDLE TIME	HRS. 0	10S 5	CHG. TO	F-NO 115

DRAW. NO.	21158	LOT NO.	58	OPER NO.	14

	MATERIALS		INSTRUCTIONS
	Not on Floor.		Lacking, or Missing.
	Lot Incomplete.		Defective, or Incomplete.
	Tags Missing.		No Blue Print.
	Not up to Machine.		Delayed for Inspection.
			Waiting at Cage.

	MACHINE		TOOLS
	Break-Down.		Lacking, or Missing.
	Repairmen Working on.		Defective, or Faulty.
X	Belt Trouble.		Delayed for Grinding.
	Power Shut-Offs.		Delayed for Supplies.

INSTRUCTIONS: — CAREFULLY CHECK ITEM CAUSING DELAY. IDLE TIME WILL NOT BE ALLOWED IF REPORT IS INCOMPLETE.	FOREMAN	E.J.
	CLERK	C.H.C.

FIG. 15

FORM IV. IDLE TIME REPORT ON WORKMAN NO. 532

per hour, when suspended from task he receives 37½ cents per hour. That is, his day work allowance is one-half of his premium earnings when under task. The next rating compensates for this allowance. (See Form IV.)

PERCENTAGE OF TIME SPENT ON NON-TASK OR STRAIGHT TIME WORK (P_d).—Discussed in the preceding paragraph.

COOPERATION AND CONDUCT (C).—Additionally, there

FORM A-1287 MPG.

WORKMAN'S RATING REPORT

NAME					CLOCK NO.			OLD RATE	NEW RATE
H.K.					532			35½	.43
NEW RATE BEGINS	MO. 5	DAY 8	YR. 16	CONTINUES UNTIL	MO. 7	DAY 1	YR. 16	REPORT ISSUED	MO. DAY YR.
PERIOD BEGINS	1	3	16	PERIOD ENDS	4	1	16	PERIOD LENGTH	650 Hrs.

FACTOR	EXPLANATION	RECORD	STANDARD
e-E	Per cent of task time earned	33.8%	33.3%
Pa	" " " absence per hour worked	3 %	0
Pd	" " " time spent on day work	17 %	10
P_L	" " " time suspended	0 %	0
S	Average cost of spoiled work per hour	$.00	0
M	No. of major processes can do	6	2
y	Years of continuous service	10.3	5
C	Conduct and co-operation	100%	100%

REMARKS: This rating determined on base rate(B)of $.25 for Crank finishers. The record is good cut down your absence all possible and hold your earnings high
The old bargaining rate of $.355 for the same performance is hereby abolished

Your record through the current period will increase or decrease your rate for the coming period.

AUTHORIZED	APPROVED	APPROVED
G.D.B.	J.S.M.	J
PRODUCTION MANAGER	SUPERINTENDENT	DEPT. FOREMAN

FIG. 16
FORM V-*a*. RATING REPORT OF WORKMAN NO. 532

The three reports, Forms V-*a*, *b*, *c*, show how one man increased his rate of pay from 35½ cents per hour, first to 43 cents, then to 49½ cents, and finally to 53½ cents.

is the general problem of cooperation and conduct. Cooperation in a special way deserves credit, since it is unexpected. Any defect in conduct, since unexpected, should cause adverse criticism. It is not the intent

at this time to discuss or reduce to factors either co-operation or conduct, although this work is planned and will soon be regularly used. It rests chiefly upon an understanding with the workers that certain well-

FORM A-1697 MFG.

9/15/16 **WORKMAN'S RATING REPORT**

NAME					CLOCK NO.			OLD RATE	NEW RATE
H.K.					532			.43	.495
NEW RATE BEGINS	MO. 7	DAY 1	YR. 16	CONTINUES UNTIL	MO. 10	DAY 1	YR. 16	REPORT ISSUED	MO. 6	DAY 30	YR. 16
PERIOD BEGINS	4	8	16	PERIOD ENDS	6	3	16	PERIOD LENGTH	450 Hrs.		

FACTOR	EXPLANATION	RECORD	STANDARD
e-E	Per cent of task time earned	42.7%	33.3%
Pa	" " " absence per hour worked	2.2%	0
Pd	" " " time spent on day work	31 %	10
P_L	" " " time suspended	0 %	0
S	Average cost of spoiled work per hour	$.00	0
M	No. of major processes can do	5¾	2
y	Years of continuous service	10.4	5
C	Conduct and co-operation	100%	100%

REMARKS:

Your record through the current period will increase or decrease your rate for the coming period.

AUTHORIZED	APPROVED	APPROVED
G. DB.	J.S.M.	J
PRODUCTION MANAGER	SUPERINTENDENT	DEPT. FOREMAN

FIG. 17
FORM V-*b*. (SEE FORM V-*a*)

defined acts of cooperation will bring extra reward, and certain unsatisfactory conduct will cause definite penalties, ranging from reduction in wages to the condition where a man's action or influence is incompatible to his supervisors and associates, with resulting discharge.

LABOR AND FIXED CHARGE COST (X).—This is the cost as adopted and used by the Accounting Department.

TIME TAKEN TO DO WORK (t).—This is the time actually taken to do the work.

This may all seem to be a very complex solution of

FORM A-1257 MFG.

12/5/16 **WORKMAN'S RATING REPORT**

NAME				CLOCK NO.			OLD RATE	NEW RATE
Mr. K.				532			495	535
NEW RATE BEGINS	MO. 9	DAY 18	YR. 16	CONTINUES UNTIL	MO. 12	DAY 18	YR. 16	REPORT ISSUED MO. 9 DAY 18 YR. 16
PERIOD BEGINS	6	3	16	PERIOD ENDS	8	26	16	PERIOD LENGTH 630 Hrs.

FACTOR	EXPLANATION	RECORD	STANDARD
e-E	Per cent of task time earned	60%	33.3%
Pa	" " " absence per hour worked	1.4%	0 %
Pd	" " " time spent on day work	6 %	10 %
P_L	" " " time suspended	0 %	0 %
S	Average cost of spoiled work per hour	$.003	$.00
M	No. of major processes can do	5¼	2
y	Years of continuous service	10.6	5
C	Conduct and co-operation	100%	100

REMARKS:

Your excellent record of premium earnings as well as low absence has put your rate up this additional amount.

Your record through the current period will increase or decrease your rate for the coming period. R.M.H.

AUTHORIZED	APPROVED	APPROVED
H. L. B.	J. S. M.	J.
PRODUCTION MANAGER	SUPERINTENDENT	DEPT. FOREMAN

FIG. 18
FORM V-*c*. (SEE FORM V-*a*)

the problem, but it seems to be the least complicated expression which will solve the problem in any satisfactory way and allow for the perpetuation of standard rules without personal differences interfering in each new rating. As a result of the application of this

rating to workers two classes immediately developed: —one, in which the worker still maintains or increases his rate, exemplified in Forms I, II, III, IV, V, VI, and Appendix I, page 174; the other, a class in which

FORM A-1101 WORKMANS DAILY STATEMENT

NAME H.K. D 5 M 32

YOUR TIME AND EARNINGS WERE AS FOLLOWS ON — MO. 11 DAY 1 YEAR 16

DATE WORKED ON MO.	DAY	DRAW. NO. WORKED ON	LOT NO.	OPER. NO.	PREM. BASE	PIECES FINISHED	TIME TAKEN HRS.	100	PREM. HRS. DUE HRS.	100
BEGUN AND FINISHED THIS DAY										
11	1	21158	56	14A	8½	35	1	2	1	8
BEGUN OR CARRIED OVER THIS DAY BUT NOT FINISHED										
11	1	21158	58	14	104	5	3	3		
CARRIED OVER AND FINISHED THIS DAY										
11	1	21158	56	14	104	6	4	5	19	0
TIME ON PRODUCTIVE DAY WORK										
									20	8
TIME ON NON-PRODUCTIVE DAY WORK									TOT. PREM.	
									OVERTIME	
TOTAL TIME ACTUALLY WORKED=							9	0		

TOTAL TIME WORKED PLUS PREMIUM HOURS EARNED PLUS OVERTIME ALLOWANCE.	HRS.	100	RATE	DOLLARS	CTS.
	29	8	.53½	15	96

FIG. 19
FORM VI-a. DAILY STATEMENT FOR WORKMAN NO. 532

the rate tends to decrease, exemplified in Appendix I, page 176. As typifying these, two cases are illustrated, the records of one worker in each class. Such records are maintained for all of the workers, and since the re-rating occurs but four times per year, it

has not caused an excessive overhead burden. It is self-evident from an inspection of these records that regardless of anything like a reasonable overhead cost, the profits to both worker and management must be

IMPORTANT

WORKMAN, ATTENTION - IF YOU FIND ANY ERROR IN THIS STATEMENT, WRITE ALL NECESSARY INFORMATION IN SPACES BELOW AND RETURN STATEMENT SAME DAY RECEIVED TO RATING DIVISION.

PAYMASTER: - MY CLAIM FOR PREMIUM IS:

DATE WORKED ON		DRAW. NO. WORKED ON	LOT NO.	OPER. NO.	PREM. TIME	PIECES FINISHED	TIME TAKEN	PREM. HOURS DUE	AMOUNT DUE	
MO.	DAY								DOLS.	CTS.
REMARKS AND EXPLANATION							TOTAL DUE			

WORKMAN'S STATEMENT

D__M CLERK'S STATEMENT

PAYMASTER'S STATEMENT

FIG. 20
FORM VI-*b*. REVERSE OF WORKMAN'S DAILY STATEMENT

very great. The statements of two of our workmen are shown as typical of the statements which they have been very free to make to those closely associated with this work. (See Appendix I, page 180.) It is our intention to continue our studies along the lines of the relative cost of training workers for standard proc-

esses, and as early as possible to work from one fundamental base rate.

This rating system was adopted and introduced in a year when workmen had practically no fear of obtaining employment wherever they desired. None of the negative or positive factors was withheld from them or modified during the many discussions with them, and the management has stood ready at any time to assist any worker who did not care to work under its provisions to positions in other industries in this territory. We feel that the plan has been rigorously tested. Not only have we had no resignations on this account, but we have also attracted a considerable number of excellent men to our force.

Chapter VII

ORGANIZATION CLASSIFICATION

THE cooperation between management and workmen and the division of work between these two branches of the industry—the third and fourth of the principles of Scientific Management as expounded by Doctor Taylor—can be plainly traced throughout the development of the science and the selection and training of the workmen, as outlined in the preceding chapters. In fact, the four fundamental principles of Scientific Management are so intimately and mutually correlated that it is quite impossible to draw sharp lines of demarkation in their practical application, or, for that matter, between the responsibilities of the management and the duties of the workmen. This in itself, though it may not seem to establish the result, does tend toward creating the necessary cooperative action and division of work, for a practical working organization built on Doctor Taylor's principles must be based on clearly defined duties for each and every individual. The organization table of our manufacturing department, Figure 21, forcibly brings out the cooperation and, at the same time, the individualism required for the successful application of Scientific Management to a modern plant engaged in the manufacture of a complex product. There is no confusion; each department, each individual has its or his own independent

duties clearly defined. Management and production are distinct, but still go hand in hand.

The Works Manager, the representative of the Company, is at the head of three divisions: the Purchasing, Engineering and Producing Departments, each one distinct and related in no way to any one of the others, except in so far as the product of one may affect the producing division, or in the performance of some special work which stimulates or assists production. For instance, the only direct connection between the Purchasing Department and the shop is that the materials required by the shop are purchased through the Purchasing Department of the organization, though there is an indirect connection in the fact that the necessary patterns are routed through the shop by the Purchasing Department—such special duty aiding the Purchasing Department in delivering to stock certain materials required for production.

The Engineering Division, consisting of the three independent sub-departments of research, design and inspection, is quite separate and has no voice in the operation of the shops. Its duties are clearly defined: the research section conducts such technical experiments as may be necessary to further the interests of the organization and performs all mechanical, chemical and physical tests; the designing department prepares the mechanical specifications, makes the drawings and maintains the alterations which are necessary for the producing division of the organization; while the inspection section passes on all purchased material before it is credited to stores, inspects finished parts, assemblies and, finally, the finished product, the automobile—*i.e.*, worked material inspection.

The Producing Division, the factory, is divided into

two main departments, the planning and executive sections, both under the direction of the Production Manager. It is in this division of the organization that the cooperation between management and workmen and the division of the work is most clearly apparent. Each one of these two main departments is subdivided into four sections, each section with specific duties and responsibilities forming connecting links between the workers and the management. The sections of the Planning Department are those of routing and equipment for production, schedules, building and equipment, and employment. Those of the Executive Department: despatch, producing, inspection, and storing and transportation of materials through the shops.

The duties of the routing and equipment for production section in the Planning Department cover the design and construction of tools, their repair and storage, specification of perishable tools and supplies to be carried, preparation of tool lists, selection and standardization of machines, maintenance of belts and attention to all power transmission problems, specifications of the size and form of materials to be carried and attention to the routing of all materials, pattern orders, parts and assemblies through the shop. In addition to these more or less routine duties, this section also decides upon the parts which constitute assemblies, prepares the assembly charts and conducts the time studies, etc., decides upon the rates to be set and prepares the instruction cards. Further, it plans the paths and stations for production of parts and assemblies. These numerous duties call for the services of a master mechanic, draftsmen, time study observers, an analysis clerk and a corps of stenographers.

The schedule section is in charge of the Production

Manager, Assistant Production Manager, manufacturing order clerks and a progress clerk. Their duties include the preparation of the schedule tape for the Control Boards, the progress charts and setting the schedule for each element entering into the construction of a car. They record the attainment of the producing division with respect to schedule and despatch and display a perpetual inventory of work in process and work in finish stores. The lot sizes are determined by them and the Control Boards set-up; they write and date all manufacturing orders, job cards, issues for materials from stores, move tickets and tags. They open and date assembly charts, date pattern and tool orders and set the maximum and minimum requisitions for unclassified stores.

The building and equipment section has duties which are somewhat foreign to the actual production of automobiles, but which are nevertheless necessary in maintaining production: They include the planning and construction of buildings, improvements to the grounds, furnishing light, heat and power to the buildings, and providing for fire protection, ventilation and sanitation. The alteration and repair of buildings and property, the maintenance of cleanliness throughout the plant, etc., also come under the jurisdiction of this section. The personnel of this section, in addition to the Works Manager and Production Manager, consists of the Superintendent, Chief Millwright, Power Plant Engineer, foremen and the necessary millwrights, electricians, janitors, watchmen and utility men.

The employment section is in charge of the Employment Manager who, in consultation with the Production Manager, Superintendent, Assistant Superintendent and the various foremen, handles all matters per-

taining to the employment and discharge of workmen, passes on rates, maintains the workmen's time and earning records, classifies the worker's qualifications and is responsible for the tool checks when workmen leave the employ of the company.

Under the Executive Department of the Producing Division, despatch is centered in the despatch room with its system of pneumatic tubes for the transmission of all shop communications and is under the immediate control of the Assistant Production Manager. The active force consists of the chief despatch clerk, a tickler clerk, route, file and machine rack clerks and a mail boy. Their duties are mostly clerical, for they consist in the proper distribution of communications to and from the shops; dating, recording and reporting on the numerous orders, tickets and memoranda interchanged between the Planning Department, the management and the workers in the shops, through the medium of the Control Boards. The carrying of all mail is also entrusted to the care of this section.

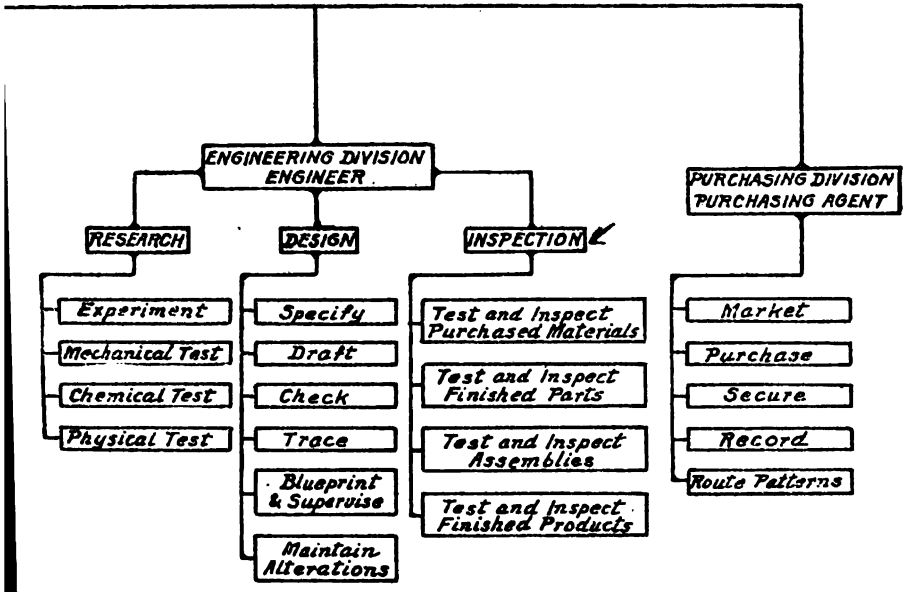
The produce section of the Executive Department sees that all orders received from the despatching section are carried out by the respective sections to which they are addressed and acts as general overseer in all matters of production activity. Both the Production Manager and the Assistant Production Manager have distinct duties to perform in this section, as have also the Superintendent and the Assistant Superintendent of the plant. The foremen of each department, the Stores' Chief with his clerks, the Transportation Clerk, movemen, elevator operators, shop inspectors and the workmen cooperate in this section to carry forward the productive activity of the organization.

The duties of the inspection section, under the Ex-

cutive Department are limited to the inspection of parts in process, which is quite separate from the inspection of the Engineering Division on worked material and to direct dealings with the workmen in respect to claims on bonus jobs, etc. The first part finished of each lot on each operation is inspected, checked with its drawing and passed upon for quality of workmanship, etc. The inspector also passes on as many subsequently finished pieces of the same part, in the same lot and on the same operation as it is possible for him to inspect and reports his findings to the foreman of the department. Any criticisms from the Engineering Division inspectors on worked materials are investigated and workers' claims of good parts on bonus jobs checked by the inspectors of this section.

The section of Store and Transport maintains the ledgers of all stores on hand and apportions manufacturing orders and assembly charts to these ledgers. The requisition of all materials called for by apportionments is cared for, and all materials received, certified as to quantity and stored. The transportation of all materials on orders from the despatch section is also a duty of this section, as is the maintenance of transporting equipment, scales, bins, etc. The Assistant Production Manager heads the section and deals with the Chief of Stores, the stockmen, movemen and the elevator men in the various buildings.

This brief explanation of the duties of the various divisions and sections of the manufacturing department of the organization, together with a study of the organization classification table (Figure 21), should make clear the cooperative feature and the equitable division of work under the Taylor System of Management as applied in the Franklin shops.


ENGINEERING DIVISION
ENGINEER
PURCHASING DIVISION
PURCHASING AGENT
RESEARCH
DESIGN
INSPECTION
Experiment
Mechanical Test
Chemical Test
Physical Test
Specify
Draft
Check
Trace
Blueprint & Supervise
Maintain Alterations
Test and Inspect Purchased Materials
Test and Inspect Finished Parts
Test and Inspect Assemblies
Test and Inspect Finished Products
Market
Purchase
Secure
Record
Route Patterns

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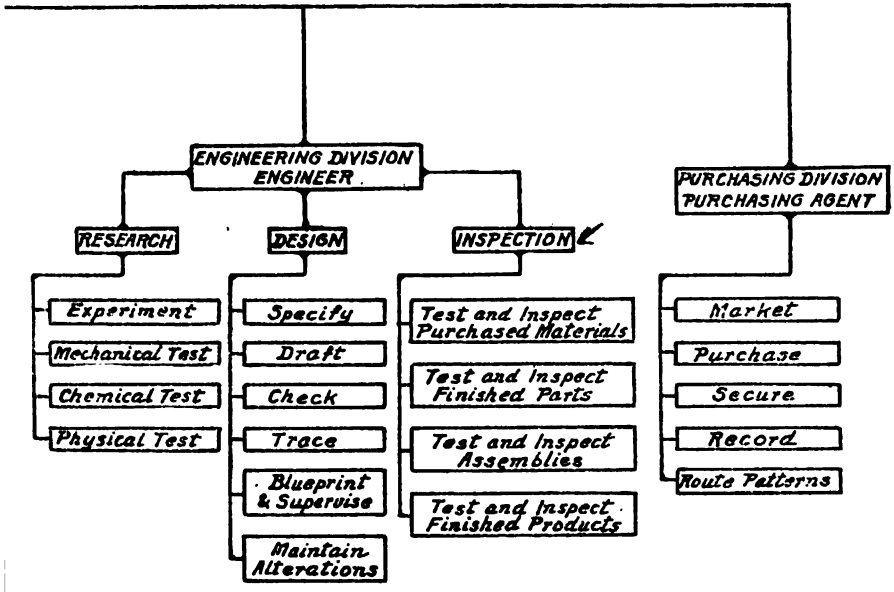

ENGINEERING DIVISION
ENGINEER
PURCHASING DIVISION
PURCHASING AGENT
RESEARCH
DESIGN
INSPECTION
Experiment
Mechanical Test
Chemical Test
Physical Test
Specify
Draft
Check
Trace
Blueprint & Supervise
Maintain Alterations
Test and Inspect Purchased Materials
Test and Inspect Finished Parts
Test and Inspect Assemblies
Test and Inspect Finished Products
Market
Purchase
Secure
Record
Route Patterns

Chapter VIII

CHANGES IN PRODUCT AND METHOD

FROM the viewpoint of the Management, and by this is meant the Company, the officials, directors and stockholders, rather than the active managerial department of the organization, the results we realized under Scientific Management may be summarized as: reduced manufacturing costs, improved product and better methods in production. These achievements are all evidenced by our steadily increasing business, the rapid and very marked increase in the size of our plant, our freedom from all labor troubles and the enviable rank attained by the Franklin car.

Through a reduced manufacturing cost, a reasonable surplus has been provided for the intensive experimental work so necessary for a continuance of progress—work which has become a pleasure rather than a contemplated hardship. The complete and accurate technical data compiled of manufacturing methods and truer costs have made an equitable expenditure for experimental work available for larger accomplishment. Better space and better apparatus have been provided, and, though probably with no influence on the ingenuity of the engineering organization, it has made it possible for them to work directly to an end after essential ideas have originated. The influence of a complex product, adding confusion and cost, as against

one more simple was so strongly indicated that the facts clearly shown added force to the then existing managerial opinion, and the variety of product was greatly reduced—on manufactured parts 62 per cent.; on special purchased parts 35 per cent., and on miscellaneous parts 19 per cent., or an average reduction in variety of 47 per cent. This change occurred from one schedule to the next. On account of a simpler product, a very much better and less costly supervision by engineering inspectors and factory supervisors could be given. It should be noted that this change occurred when, except in a very few cases, automobile manufacturers were making a very large variety of cars in relatively limited quantities.

By virtue of the standards established, it was possible to determine the length of time work should be in process from the date of requisition of material to the shipping of finished product. In this the time allowance for the purchasing agent to bargain, buy, and deliver to stores was a large part. Requisitions are explicit regarding the time for delivery of material on definite dates. The time allowed for the purchase of each kind of material as it repeats for succeeding schedules is established to agree with the purchasing agent's request, and this time is unfailingly guaranteed by the manufacturing department. In every case the purchasing agent now has opportunity to select for quality at minimum price.

The specific delivery of our materials to the inspectors at a pre-determined time ahead of the date due to issue to the shops allows a period for inspection as inflexible as that for purchasing. It is apportioned in amount to the needs as expressed by the inspectors. Lots requiring chemical analysis are never rushed

through to relieve a shortage in the shops, and, although, as is always the case where men must do things, mistakes are made, the proportion is negligible compared to errors where definiteness with regard to purchase time, dates of delivery of material, or allowance for inspection is ignored. Incidentally there has come a benefit to product through the stores handling —a marked reduction in losses due to shop-worn parts, storage batteries "alive" due to frequent turn-over, and tires equipped only of the latest serial numbers. That is, the orderly arrangement and scientific treatment of materials, especially finished purchased goods, have greatly enhanced the quality of the product as delivered to the customer. Parts or materials rejected by inspectors as being unfit for use are controlled as intensely as the useful ones, eliminating any chance of being accidentally re-routed into production.

In the stores room a reasonable time is allowed for the stores men and the move men to prepare and ship their material to the shops in good condition under an economical "ton-mile" load. In the shops set times are allowed for each production operation, a standard allowance time between operations, and time for parts inspection at each operation for reasonable flexibility and opportunity to care for unusual happenings. Under the lot plan this causes only a temporary delay to the product and none at all to the workers if some of the parts are in need of repair, owing to incomplete work which may have been overlooked by the man or caused by carelessness on his part, or some defect in the tool which he used. There is not the pressure coming from a large number of men waiting in line for that part, because the work which each is to do has been planned for him only after an allowance of time

has passed. The allowance time is such time between operations as the product is supposed to lie temporarily idle. The lot size or "reservoir" may be as small or as large as desired, so long as the man changes to other work when it reaches a certain low level. The practical certainty of control on account of known time for the different operations and the intensive regulation of materials and tools between operations, precludes the need of rushing work; although at times this has been done on certain parts, it is not in any way a common practice, and it is very rare that a standard lot size, after once started on an operation, is broken down to make room for a "short" part.

The extreme care which is exercised in the control and handling of well-designed tools in shops and tool rooms eliminates much chance of poor work going into poor product or high scrap cost. The workers on standard lots act strictly as individuals, and maintain rates of effort, in no way influenced by any other worker. That is, the lot on which they are working is not wanted by any other worker and is not anticipated by anyone until it is completely finished on its previous operation; it is not considered available for future work until it is finished and has passed inspection. With due allowance time, floor inspection can be carried on without detriment to the schedules, since inspection time is recognized as part of the producing time and has been standardized as such. This is true with final inspection and with any mechanical assemblies. According to the product classification, single parts are assembled into small units; the units again assembled into larger ones.

As each of these units is assembled it passes through inspection. Not only are the pieces inspected as such,

but they are inspected in each of the subsequent units as a check for their fitness in the making of the unit. Work which may be found by the inspectors to be incomplete is sent for repair, not to the workman to rush through on his own time, but rather to a repairs department in which special machinery and skilled men are segregated for the purpose. Such parts receive extra inspection from the engineers, and are used only when the repair can exactly satisfy the original specification. This permits the work to move with rapidity and gathers up such parts as can be readily repaired and returned to production. The responsibility for such repairs is accounted for by the workman or tool department at a subsequent rating period.

The improvement and uniformity in product which this care has brought about has made it possible for us practically to reproduce a complicated assembly made up through some 12,000 distinct operations, so that there is very little choice in the finished product. There was a time when dealers would solicit responsible persons to "pick out a good car for them." It is so long since we have been approached on such a subject that we had almost forgotten that it ever occurred. This uniformity in reproduction has brought a standard of quality to create a confidence in our repeat purchasers that is in itself no small satisfaction. Not only have the mechanical engineering features been consistently developed, but it has seemed possible to add many niceties to the product and to improve quality of fittings and accessories in the face of reduced sales prices, higher wages, and greater profits.

In manufacturing methods there has been a marked development in apparatus for parts and in ways and means of producing assemblies. Many influences be-

sides system and Taylor methods have acted, it is true, but only by close observation and from records compiled during the years of practice of the Taylor System are we able to localize improvements as due to this system or caused by other things.

The old method of supervising manufacture was approximately as follows: Each manufacturing order called for a miscellaneous part or assembly, and the assembly order contained a specification of the parts which were to be used in that assembly. Part orders were written quite independently of the requisition for material, and no date was specified for the part to be due in finished stores. The orders were written for quantities of 25, 50, 75, and 100; and in general it did not matter whether the part was small or large, except in the case of automatic, screw machine, or punch work, when an order for the full quantity for the season was usually written. These orders were not apportioned to the material ledgers, and therefore it was a case for the most persuasive foreman to get from stores the material for his parts. He could draw from stores on requisition at any time he could find some material; and, unless he had a shortage notice, could finish his order at any time he saw fit. He had a schedule for parts to guide him. This consisted merely of a schedule for a month's production of the different types of cars, set back as many months as our progress clerk assumed the work would need to start and be delivered in time to the finished store-room for issue to assembly. We had but few small assemblies. A single group issue for one of our large assemblies might demand as high as a quarter of the variety of parts in the finished stores.

After the assembly order was issued it was given

to the finished-stores keeper, who was required to deliver the materials to assembly against that order as rapidly as possible. When first parts of the lot were delivered to the assembly floor, the assemblers started, put them together, and from that time on tracers tried to force the parts which were lacking through the shops on the remaining operations and in and out of the finished-stores room to the assembly floor. It was a merry chase.

One result of this was that operation set-ups varied from one to one hundred pieces, and on the same part might vary in this complete scale.

With an average of ten operations on different drawing numbers, or parts, to each machine, and with the preparation time of the machines uncertain, confusion resulted by interference of orders from the different shortage chasers. Very high costs were thus created.

However, we produced cars for a number of years under these conditions, and still believe that we represented a high order of working efficiency in the automobile industry of the time. In fact, there are many plants which, even now, are operated under very similar conditions in the belief that they are efficient.

Engineering changes in those days were frequent, the demands of the buying public uncertain; and at that time it seemed to us such changes were the only way of solving the problem.

Now we can see how it could have been solved in a very much better way even with full complications of a variety of models and many changes.

When we began the classification of our product the elimination of this confusion and trouble also began. Through the findings by the classification of this prod-

uct, our whole scheme of control of work has come about.

We were impressed with the fact that in a complex assembled product the least unbalance in production of single parts or groups must invariably cause congestion of work in process and materials in storage, and also a temporary suspension of work in some divisions followed by a corresponding period of excessive activity. There would first be unemployment and then overemployment; part of the plant and machines idle, and later greatly under needed capacity. Delayed or limited materials may easily be the cause of a greater congestion than material well in advance of schedules. Either condition causes not only extreme dissatisfaction to the persons affected, but it means an unnecessarily large permanent investment in buildings and fixed equipment, as well as in material and labor. A uniform burden on the works at a minimum investment charge is so desirable that all possible effort to accomplish it will be repaid.

This result can best be accomplished if a classified product with standardized methods is managed by an appropriate control plan continuously and intelligently applied. Through the mechanism of our Control Boards and a lateral movement of the strips on which the operation cages are placed, the re-scheduling of our operations on a part, as was explained in Chapter V, is easily obtained. This mechanical adjustment is no particular hardship for the clerks, so there is no reason why full advantage of any improvement in shortening in mechanical methods, no matter how slight, cannot be taken.

Among the many beneficial standards we have established is that of machine-hour burdens as used for the

control of working capacity and to stabilize the continuity of service of the worker. What machines and how many for a given rate of output for a known product—the deciding factors—is a perplexing question.

Expert mechanics of highly inventive ability in the planning room will specify the first part of this question; *i.e.*, "What machines?" The regulation of "How many?" to produce a varying schedule of output can then be secured through exact record of the time in which the machine can produce each operation on each piece which is routed over it. If the product is one similar to that now considered, a burden record can be compiled to show each machine, by number or symbol, with all operation time routed to it, for one unit of the finished product. The sum of such time for each machine multiplied by the number of product units to be made each day will give the daily task. This daily task divided by the number of machines will give the daily burden. This burden divided by the number of time units in a standard day will show the number of machines required.

Two essentials for the success of this plan are: proper time allowance for machine break-downs or idleness, and exact knowledge of unit times for operations. There is no way of securing this latter except by elemental time study. Since the machine operator's activity is a factor in the time taken by the machine, the operator must accomplish his effort in the set time. This is prescribed in the instruction card with which the operator is provided. Regardless of the payment of a premium or bonus to the man for special attainments, it is absolutely essential for the welfare of his fellows, as well as for the stability of the business,

that the machine unit times be obtained and applied. Any delay of a part causes a delay of the assembly into which it goes, with a consequent suspension of work in the assemblies.

The operations on parts that go over each machine having been recorded, from the schedule of the particular operation of that part which must be first worked upon, a date can be given for the delivery of the machine to its place on the work floor.

Any machines planned for the same time and quality of work are speeded, powered, and made exactly alike in all mechanical respects. They are then classed in groups, so that work routed to one can be placed upon any of the others with certainty of predetermined standard performance. The group carries the group burden, and in all respects acts as one machine. Each machine in the group is regularly inspected and repaired.

If two or more operations on different parts must come to the same fixture in the path of their progress to the product, the order in which they shall come and the length of time the fixture can be applied to any one of the parts is a fundamental of the control of schedules, and is, quite obviously, dependent upon the "lot quantity." I am well satisfied that by establishing a standard lot quantity for each of the parts, so that in any given "set-up" the run of that set-up can be reasonably economical, is an entirely satisfactory way of dealing with this complex requirement—*i.e.*, the quantity of output should be governed by the frequency of starting lots. If the "lot size" is too large, other parts routed to that fixture will fall behind; if too small, the frequency of change may be too great. This does not preclude a continuous run on any one

operation if a sufficient number of lots of the same kind succeed in reaching the fixture before another part is due at the same fixture.

If a complex product, such as the automobile, typesetting machine, player piano, or any such complicated assembly, is made in quantities under 6,000 per year of one type, there is practically no chance to take advantage of one operation at one machine for one workman. Single mechanical operations on such product, due to the smallness of the parts and the speed at which the work can be done, require usually much less than 25 minutes. It will require 25 minutes for any operation on a production of 6,000 to give a full year's work to one operator. The frequency of change of operations can be determined by dividing the number of minutes in the working hours of the year, normally (27,000 hours) (152,000 minutes), by the number of pieces to be made in the year. This will give the number of minutes per part allowed for the operation which, compared to the number of minutes which the operation will take, indicates thereby the total number of changes which will occur. From this will be found, in a very large part of industry, that there is slight danger of workmen operating as specialists even if they so desire.

We established standard lot sizes early in 1912, and only within recent months have our schedules increased to the point that continuous uninterrupted manufacture on one part may be economically carried out. If the lot size has been accurately determined, and very strict regulations put into force that a lot once started cannot be broken, the control of frequencies of change at machines is at once possible under a centralized control department.

There is a strong tendency shown by manufacturers, who merely imitate the methods of some of their competitors, to overlook quantities of product as being one of the fundamental requirements for such use. In the kinds of products above mentioned, a change in quantity from 6,000 to 15,000 per year, if economically made, will call for almost different forms of shops, of methods, of machine lay-outs, and of workmen. In the first place, with a variety of operations in limited quantity, "all round" skilled men and standard machines are handled. In the second case, where larger quantities for special machinery and specialists trained only in the one operation are required, for maximum economy, there must be a firm determination that the quantities produced are far enough away from the median between the two to make one method or the other a standard of practice. The application of particular methods can be determined readily through a study of time required for various classes of productive effort. In industrial processes they will include the following requirements, indicated by orders of work, arranged from the lowest to the highest order in manufacturing efficiency:

(a) One order for one piece. The piece never to be reproduced.
(b) One order for several pieces, never to be reproduced.
(c) Repeat orders at irregular intervals for one or few pieces.
(d) Repeat orders at irregular intervals for many pieces.
(e) Repeat orders at uniform intervals for one or a few pieces.

(f) Repeat orders at uniform intervals for many pieces.
(g) Continuous or standing orders for the same piece.

Any industry may have in combination one or more of these classes of effort and in any analysis of the industry this should be recognized. The industry should be classified into the above classes and a control plan devised in such a manner as will secure the best results for each class. A general control plan will then be devised so as to relate the classes.

Forms are so constantly mentioned in connection with any manufacturing system that to understand clearly what forms are for is to better understand some of the causes for changed conditions which have been related.

To carry out system practically, it is necessary to provide for the distribution of instructions to the interested persons. Forms are used for this purpose. They should be considered as instructions developed from the fundamental laws of system; and, if those laws be changed, forms must also be changed. It is convenient, at times, if the change is but temporary, to instruct through the medium of memorandum or letter, but under no circumstances should any change in the use of a form be allowed unless by written instructions from the responsible person in charge. The fewer the forms that can be used to carry out the instructions, the easier will be the above problem, but they are of little value unless they convey specific information.

At the beginning of our work, a study of the plan of supervision developed the fact that the manufacture consisted almost entirely of classes (c) and (d) in the foregoing classification.

This was considered undesirable for the extensive manufacture which was being done. It was caused by:

First: A variety of models and, consequently, of parts in small quantities;

Second: A schedule of shipments for finished product which was affected by the seasons and was therefore irregular.

The quantity of production was sufficient to give economical returns under good shop practice, and in fact the Company was enjoying prosperity. As it was its desire, however, to reduce the sale price of the product to the lowest possible point, an entire revamping of methods was considered. Briefly the following method was pursued.

The time taken to perform each operation on the part of each machine was determined by estimate or by actual practice. The operation times were then grouped by machines and compared.

A study of the grouping indicated too large a variety for manufacture under class (g); *i.e.*, "Continuous or standing orders for the same piece." This was because the product is high in quality and requires a great amount of careful workmanship; the initial materials are costly; the lowest possible sales price is therefore larger than for a cheap product and the demand is necessarily considerably less.

Through the simplification of models and the change in the delivery of the finished product to our sales organization, we were able to modify the effort and bring it into the next to the highest class of manufacturing effort, (f)—*i.e.*, "Repeat orders at uniform intervals for many pieces"—with a small proportion of the product under class (g). However, since there was

but a relatively small amount of the latter class or of the first or irregular classes, we decided to plan our main control for the one class only, that is (f). All irregular classes, such as toolwork, machine repair, manufacture of sundry parts, plant repair, etc., are segregated in a separate shop. Class (g), or continuous production, is considered and controlled as for class (f), repeat orders. All cases of class (e) are obviously controlled as for class (f), repeat orders.

The impression has become so grounded that the Taylor System is a set of fixed forms and methods that I am forced to say that in no case have we found this to maintain. But quite in opposition to this we have found that as product and machinery change—and possibly even more than do these—rules and regulations, fixtures, and methods of Scientific Management are as subject to alteration and change. As trained engineers must be alive to their opportunities to change of designs and as factory mechanics to the change of machines for more economical returns, just so must those in charge of the conduct of management in the Taylor System be alert to the designing of ways and means to meet the complexities of changing factors which they must supervise.

Chapter IX

CHANGES WHICH HAVE AFFECTED THE MEN

GRATIFYING as have been the results brought about by the changes in product and methods, they would be of only secondary importance should the gains not be permanent and assured of continued betterment. As knowledge once gained and properly recorded is not readily lost sight of, there should be no question of the permanency of gains already realized. As for continued betterment, this can only be assured if the men have gained and benefited with and in proportion to the realizations of the company. If this has been true, a continuance of improvement cannot fail to come about.

Summarized, the most pronounced results which have affected the men are: largely reduced turn-over of labor, larger percentage of permanently employed, higher earnings per worker as recompense for greater achievement, greater satisfaction in accomplishment, materially increased knowledge of shops practices and office methods, relief from unfair responsibilities, better living conditions, shorter working hours and the generally accepted attitude and understanding that the management is to *serve the worker* in full measure as his, the worker's, industry serves the management.

The matter of labor turn-over and the insecurity of

employment are such important considerations, both from the viewpoint of the workers and the management, that they are receiving to-day a large amount of attention from organizations throughout the country, including the chambers of commerce, many of which have established boards for research leading to a correction of this very evident evil. In an address before the National Metal Trades Association, at Worcester, in April, 1914, I gave this subject an introductory and prominent part. Quoting from the address:

"If a community could so select its industries that the average peaks of laborers employed in all of the individual industries gave a uniform load of labor in the community, it would be well worth the time of the civic organizations to try to secure such industries for their community as would tend to level this peak load. Of course, if individual industries could level their particular load, this would automatically care for itself. Although this can be approached in a very marked way, it cannot be as perfect as in the case where industries have been selected by a community for this particular quality.

"Some causes of peak load in the employment of workmen, beside that of management, are uncertainty of demand for product, seasonable demand for product, small capital invested in the business, strong competition with small margin of profit. Any of which can be materially improved by plans founded upon analytical study."

I have not only not changed my opinion in any sense since that time, but have become more firmly convinced that this is one of the largest possible fields for action in managerial matters. A low labor turn-over

is, in general, indicative not alone of good management, as far as product control is concerned, but an excellent indicator of the human relations between management and men.

In December, 1915, a study was made of the relative turn-over of labor in departments in our works operating under our new methods of management and those still under the older form. We found in the automobile shops where the improvements had been longest applied, that 20 per cent. of the force were over 50 years of age; 5 per cent. over 60; and the average age was 37. The average period of last employment for the whole force was four years, for one-half of the force selected was six years. By last employment I mean that a worker had at no time been out of our employ in the period.

In a review of the men on the pay-rolls at the beginnings of various years who were still in our employ in January, 1916, we found the following percentages:

Since January 1, 1912, 51 per cent.
Since January 1, 1913, 80 per cent.
Since January 1, 1914, 86 per cent.
Since January 1, 1915, 90 per cent.

Comparing these records with conditions as they existed in 1911, the improvement is surprising. In the Motor Car Department in that year, prior to any active application of Scientific Management, our labor turnover records showed that 16.9 per cent. of the men employed were laid off during the year, for one reason or another; 47.5 per cent. resigned and 9.2 per cent. were discharged.

Another evil which bears very directly upon the question of labor turn-over, one which is frequently a con-

tributory cause therefor, is the question of absences and tardiness. It was not until 1913 that we had accurately recorded data as to lates and absences, so that comparison can only be made after a partial instruction of Scientific Management. The improvement, however, is marked. In 1913, the number of times late compared to total hours worked was 0.2 per cent.; hours lost by lates and absences compared to total hours worked 3.6 per cent. In 1915, times late compared to hours worked 0.09 per cent.; hours lost by lates and absences compared to total hours worked 2.9 per cent. While the relation of lates to hours worked is but an indicator, it is nevertheless permissible for comparative purposes, since the hours worked are proportional to the number of men employed.

The permanency in employment and reduction in labor turn-over made possible under our system of management was well exemplified in 1916. A new model was brought out in that year which differed so materially from our previous products that it was deemed advisable completely to obsolete all parts made prior to July of that year and to produce a complete new set of parts. This necessitated a complete change in jigs and fixtures, perishable tools and even machinery, for the operations on the new parts differed from those for previous models. As the old work was wound up, it was impossible to avoid laying off some of the men, but the shrinkage in number of old workers was not only in no sense serious, but the force was at the same time being increased from about 1,600 to 2,400 men, and this considerable increase in employment was made in the face of an unusual scarcity of workmen. Furthermore, it was necessary that the men employed be general workmen and not operation specialists. Our

turn-over in this new force, which has now become permanently fixed, did not exceed 50 per cent. of the number of men on the pay-roll at the end of the year.

Lack of skill on the part of men who apply for mechanical work, and in times of pressure the lack of time in which to train them, is one of the large causes of our labor change. So many more men must be employed to carry out a task than are finally required after they have become skilled and adapted to their task, that there must come a time when a considerable reduction in number is necessitated. In fact, this is one of the real regrets of a manager who is obliged to employ a somewhat untrained force in larger numbers than should be required to get out the work; and as this force becomes skilled, to reduce it by the necessary lay-off of men who have earnestly tried to bring the production up to the sales requirement. Happily, our schedules have so increased that this has not occurred to an appreciable extent. Those who do go, furthermore, take with them acquired skill which is of great aid in establishing future permanency.

There is little question but that the average earnings of our workmen with decreased work hours are greater than in any shops of which we know in this employing district. Even prior to the time when our method of rating workers began to show its effect, late in 1916, wage rates were not increased intentionally to compete with other employers, and the fact that there were no losses from our force is unquestionably due to the equity we have always aimed to establish in our dealings. Our men earned their increased wages and received them as a simple question of justice.

To keep our workmen employed it has been essential

that costs either remain at least at the same levels or decrease. If a wage increase in a given industry increases the product cost more than the ingenuity of the planning department or suggestions of workers or other efforts can decrease it, there is sure to come an outside vendor offering to manufacture and sell to us those very articles at less than our own costs. No manager, however philanthropic he may be, can conscientiously retain the work in his shops in the face of such a bid. If the sale price of his product remains the same and he does continue to manufacture with cost increases due to high wages, the gross profits of the business will naturally be less, and the distribution of earnings to workers and stockholders must in turn be less than if the local work had not been continued. If the business goes, the workers in the local industry are naturally laid off for an indeterminate period. If the vendor taking the business is not in the immediate vicinity, it is a long time before the employment of men caused by his new business reaches out to include those who have been laid off. It is further evident that if his wage rates happen, as is probably the case, to be lower, the worker so laid off must take the lower rate upon re-employment. This is but one of the many necessary conditions which arises where wage rates, larger than customary, increase costs. This was considered at the time of our studies which led up to the *relative rating of workers.* And, as has been observed, the influence of the workers upon fixed charge savings, his savings by virtue of attendance and acquired skill and low spoilage losses, were provided as a part of the extra recompense for the high wage without corresponding increase in the total cost of the product. This matter of increased earnings was discussed so

thoroughly in Chapter VI that it does not seem necessary to repeat it here.

No small part of the comfort at the end of a day comes from the satisfaction of having done a good job. The satisfaction is just as great for the worker at his machine during the day who, by acquired knowledge, materially increases his output with a minimum of fatigue and a minimum of product loss. It is very discouraging to find after a large amount of work has been done, that tools were slightly defective, that machines were not precise, or that the measuring instruments or gauges had varied from the required dimensions. I believe a workman is for this cause more depressed (a depression materially enhanced by the criticism on the part of his supervisor), than he could possibly be because of the loss of extra earnings. Under present conditions there is practically no indefiniteness as to what is to be done, or how it is to be done, or when it is to be done, or what it is to be done with, or the time it is to take; and I am satisfied that my relations are close enough to our workers so that they know that the things which are discouraging to them will receive a considerable portion of my personal attention. They have been free, and have taken full advantage of their privilege, to criticise poor conditions. I am happy to say that they have not forgotten to express their appreciation as improvements occur.

One of the features of the Taylor System is an instruction card as a part of an educational system which is not excelled, and I am sure not equalled, in any of the educational institutions which teach shop practice or manual arts. Not only are the very best mechanical devices provided that the most ingenious men can

think of, but the instructions for their use are extraordinarily well prepared and transmitted to the users.

During 1916, because of complete change of design, we faced the problem of obsoleting all of the parts that were in our production standards up to June 1st. For the new product an entirely new set of parts requiring new tools and methods and new information were put into process. I am safe in saying that if the drawings and material had been turned over to our shop force, left to their own devices to produce the parts, we would not have completed a single car in the remaining six months of the year. Not but that they could have in the meantime studied ways and means, but, since nearly 130,000 producing hours were spent in the designing and making of tools alone, a good share of the force would have devoted much time to this work, and when done would have provided no plans for transmitting instructions as to use. Under the operation of our present system of departmental assignment and work performed by those best fitted to undertake it, on the contrary, there was but a temporary let-up in production, and by the beginning of October five hundred and sixty-odd new model cars had been produced. Following this re-establishment of productive activity, the rate of production has increased much more steadily than at any other period, and by June of 1917 the daily car production reached forty-five.

There is always the matter of fitness for a task to be considered, and anyone could well understand the lack of judgment in requiring the design and construction of tools by men accustomed to the shops, as against men trained in the skill of designing and drafting. The results attained leave no question of doubt.

We seek for suggestions from our workmen, and we try in every way to encourage them to personal development along original lines, but we find it most difficult to apply economically such suggestions as could possibly be used out of the very limited number submitted. In general, the worker is so busy with the task at hand, whether it be in office or shop, and his free hours are naturally spent in pursuit of his own affairs, that practically very little opportunity presents itself even to those who strive to aid through the suggestion box.

One of Doctor Taylor's well-remembered statements is that he "would not require bricks to be made without straw." I believe that a very large percentage of shop workers in this country have that requirement put up to them practically every hour of the working day. Happily in recent years the change from this condition is rapidly coming to better things. To demand that a shop foreman produce his schedule, and not to consider or to know that he is properly supplied with ways and means, is but transmitted from him to the worker. They both accept the orders in silence, and the one giving them is deceived into believing that within the time set the result will be obtained. The surprising thing to me is how many times one giving such an order can stand the regularity with which it fails to mature. One of the strongest teachings of Doctor Taylor, and one most vigorously practiced in Scientific Management, is that of issuing the order to do the work only after all auxiliary orders providing for it have been executed. The workman is thus not officially called upon to accept responsibilities until they become his by virtue of the completed preliminaries.

An analytical study in a factory with high costs

quickly indicates the need of good working conditions for the man. Rigidly set and well guarded machines will remove the fear of rapid operation from the chance that "something" may happen. Only owls and bats move around with reasonable freedom in the dark, and illumination is so cheap in proportion to spoiled work that from a financial standpoint alone the improvement of a dark condition cannot be ignored. Aisles restricted by piles of materials, greasy floors and insecure overhead structures cannot be tolerated in a shop where efficient operation is a part of the program. Clean windows, pleasant outlooks, good ventilation, sanitation, and heat will all reduce labor turnover to a marked degree and bring a sense of good-fellowship and comfort to those who associate in this environment.

We have been fortunate, through records from the Mutual Benefit Association (an organization composed, controlled and financed entirely by the workers), to obtain a record of the men on sick leave for five years. This report is shown herewith quarterly for better comparison. It lacks anything to indicate sickness or overwork brought on by so-called "speeding up" methods.

PER CENT. OF MEN WHO RECEIVED BENEFIT

	1911	1912	1913	1914	1915
1st Quarter	11.1%	10.8%	9.7%	12.0%	12.7%
2nd "	8.2	13.9	8.4	9.5	10.2
3rd "	5.2	9.6	9.6	8.3	8.0
4th "	7.7	7.9	8.1	8.4	6.9
AVERAGES	8.2%	9.3%	9.0%	9.6%	9.1%

A complete knowledge of what is to be done and this knowledge given to the workman by written instructions, allow quite unskilled men to become skilful. Em-

ploying men for what they can learn to do, and not for what they know, makes rather an easy task for the Employment Superintendent. Employment centered in a representative of the chief factory executive, and discharge possible only on written approval from this executive, secures steady permanent workmen. Wages sufficient to allow interest in outside investments, working hours which allow time to supervise and enjoy such an investment, and continuity of employment assuring a permanency of this investment, add materially in establishing the force and assure a steady high-grade output.

Where large quantities of the same part and the limited performance of a special machine are continuous, men are naturally employed on limited work. This limited work is not a function of a particular kind of plan, but rather an economic specialization true in all branches of mechanical activity, from the engineer on a limited train to the farmer at his plow. The miles to go or the acres in the field limit the frequency of change of application of effort.

The management no longer issues orders and assumes little responsibility, but now it issues educational orders with detailed instructions and assumes the full responsibility of the accomplishment. The worker is practically never called upon for an explanation as to why this or that did not happen, except in a case where a worker has failed to accomplish those things which are both for his best interests and those of the management. When the little particles which do sift through the managerial screen are again worked over, there will be none left unconsidered. In the best managerial plan it is to be expected that some unobserved conditions will exist, and it was not until we

had developed our close relations to our workers through our rating plan that we were able to bring them practically to the 100 per cent. basis. Since intimate relationships have been established with the men, investigations are maintained, corrections striven for and adjustments brought about, whenever possible, until each legitimately dissatisfied worker is convinced that any departmental conditions affecting him has been settled to his best interests. In every investigation, it may be added, the management has profited in every particular as has the worker. The management assumes its responsibilities and the workman assumes his.

The plan of dual responsibility under old methods showed the usual weaknesses of indecisions in emergency, lack of correction for faults due to uncertain responsibilities, and distrust due to lack of knowledge. Opinion was pitted against opinion, and a general feeling of indefiniteness permeated the factory atmosphere. Dates called for by the management were not kept by the foreman, primarily because the time duration of events were uncertain and irregular. Material shortages were frequent; tools were unsuitable and lacking; machines were not suited to the purpose and in poor repair; tools or machines were not standardized, and work could not be rapidly exchanged from one to another. Shortages of parts were constant and serious, causing a very high percentage of preparation in operating time; through this inefficiency a high peak of workman effort resulted. The change in number of employees was frequent. A large percentage of employees were poorly trained and irregular in attendance.

Under the present system of management: single

responsibility has brought rapid decision; faults are few, and causes are exactly determined; there is no indefiniteness with respect to any element of effort in the plant; dates planned for are almost exactly met in a large percentage of events, for if failure to keep dates is imminent, all available help can be concentrated at once on the weakness to make a rapid correction. Material shortages are small and infrequent, and parts shortages are also infrequent and never serious; while tools and machines are kept in first-class condition and are especially selected for the required task. The percentage of operating to preparing time is high and practically constant. Employees are much better trained and show less avoidable absence; and as there is practically no peak load of effort, there is consequently little change in numbers of employees. Rates of earning show a marked increase, while cost of comparative product shows a marked decrease.

Time study has been of great value in arriving at these results, particularly in the question of dates, where it has proved even more useful than it has in application of working costs.

As typical of the change in conditions, I quote from a communication of September, 1916, by our Purchasing Agent, which is characteristic:

"Having had over twelve years of experience in buying for the H. H. Franklin Mfg. Company, the writer has naturally seen some inside development in automobile manufacture. In the early days, and in fact even up to a few years ago, it was not an uncommon sight to see the whole purchasing staff in the office at nights for two or three hours' work, working not because business was so good, nor necessarily because it was so bad either, but largely because we did not

know just what materials we wanted or when we wanted them.

"Our scheme for requisitioning and buying had always been crude and largely represented guess-work. That is, when a requisition was issued we were not always sure just what spoilage or other loss we might experience, and consequently it often happened that we had too little stock or material to finish the job, or perhaps we had altogether too much.

"Furthermore, we had carried on no systematic time study and therefore we did not always know, in fact, we very seldom actually knew, just when the material would be wanted for the next batch of orders. In a great many cases this all meant long distance telephone calls, telegraphic messages, and perhaps someone was sent to stay with the source of supply until the rush shipment could be made, and then came enormous express charges.

"But worse than these conditions, we were not infrequently held up seriously in production, which meant the laying off of men, loss of organization, and no finished cars, then a wail from the sales department and dealers, to say nothing about the cry from the treasurer's office because there were not enough receipts to pay the bills.

"Then, on the other hand, we often received materials considerably in advance of our needs, which meant another cry from the treasurer's office and stock keepers because of too much stock and of too heavy an investment. You would be amazed, too, if you were made familiar with some of the usual large manufacturers' losses through surplus or 'dead stock' accounts.

"The purchasing department always 'caught it,' both coming and going, and those were the days we

really worked—acted first, then analyzed, then tried to adjust.

"All of these conditions caused an enormous cost in overhead and production, but of course the consumer was expected to pay all the costs and offer no criticism.

"To-day, these conditions are changed. We hardly ever cancel or hold up an order now, whereas we used to spend as much time cancelling or holding up orders or changing specifications as was spent in issuing the original specifications. Our sources of supply would corroborate this statement.

"We issued about 20,000 orders last year and will probably place from 22,000 to 23,000 this year. Our purchases are easily ten times what they used to be, and yet less effort is expended in this department for meeting the needs of the works.

"It is only fair to state that when the Taylor System was first being studied years ago, we did not become particularly enthused, but it was not long before we could easily appreciate that a future for the Franklin Company was in sight.

"Before any requisitions are delivered to this department, the requirements are carefully analyzed so that deliveries may be arranged early enough and yet not too early. Notwithstanding our materially increased production, our stores investment is lower than ever before.

"This department keeps the manufacturing department informed at all times concerning market conditions, recommending purchases on account of delivery conditions such as now confront us, and keeping them informed regarding price fluctuations.

"We advise them, too, regarding the length of time

desired for obtaining materials; always itemizing, because these conditions, as all will readily appreciate, require frequent changes. This enables the manufacturing department to chart their requirements, and leaves little or no excuse for late specifications and subsequent tardy deliveries.

"Furthermore, we now have an accurate and earlier line-up of costs. We used to price parts after the materials had been delivered to us. Now we price easily 95 per cent. of our orders when they are placed.

"Our accounting department, as well as our production department, is given copies of all orders, and is therefore always in possession of figures showing our obligations and costs for all purchases.

"Naturally, it is necessary to have some sort of follow-up system to know that specifications are properly cared for, but this is easily looked after by reviewing a small block of orders each day, and completing a canvass of all orders at least once each week."

Since the personnel of the organization which is now carrying on our managerial work is practically as before Mr. Barth's first visit in 1908, and since improvements in practically every direction have been marked, I believe that the chief cause which led to it is our change of attitude toward the problem gained through Taylor principles for the carrying on of the manufacturing effort. The changes came gradually: First, better stores—receiving, storage and accounting; second, better classification of product, tools, and methods; third, better controlling plans; fourth, adoption of time studies and rate standardization; fifth, new machines and equipment. Each of these changes occurred at different stages, and product costs which were checked against each of the stages show the rela-

tive effect. In none was the change more pronounced than that of better control. This was to be expected, since the control was merely a co-ordination of all of the others.

We are obliged to conclude that the Taylor System in Franklin Management has been successful in reaching useful ends, which it would appear could not be attained without it; that instead of substituting for executive ability, it depends greatly upon this for its success. It does not in any sense eradicate the human element, but brings forth the very best that is in men or women subject to its influences. It is very important that form or method be eliminated as fundamental for Scientific Management, for it is only through a scientific study of the problem to be solved that the correct solution will be indicated.

Chapter X

THE RESULTS GRAPHICALLY DEPICTED[1]

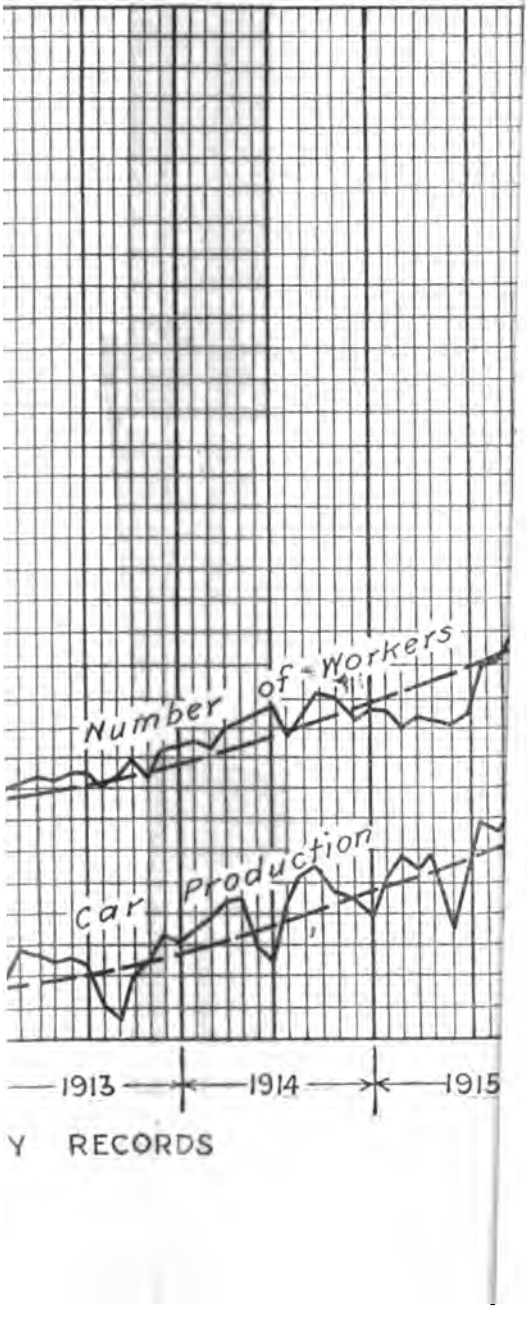
AN analytical review of the results attained under the Taylor System of Management at the Franklin plant, during the five years it has been in effective operation, shows a number of desirable gains. The organization has grown and apparently prospered, while at the same time the workers have been materially benefited. A spirit of cooperation and mutual respect permeates the shops. Capital and Labor seem to have buried the hatchet, as is evidenced by the freedom from all labor troubles. The workers appear contented, energetic and desirous of increasing their knowledge and efficiency, while the organization shows a firm and healthy development.

The growth and activities of the industry are graphically shown on Chart I, which depicts not only the increased production of cars month by month, but also records the number of workers employed—from the middle of 1908, when the introduction of Scientific Management was first taken under advisement, until the summer of 1917. The increase in the monthly production of cars might not alone indicate the marked and continuous growth which has been made by the organization, but when the proportional increase in the number of workers employed is taken into consideration there can remain no question as to the expansion of the business. It will be noted that the lines depicting production and employment are quite similar in

[1] By Reginald Trautschold.

their general trend; that is, when many cars were produced a corresponding large number of workers were employed.

Scientific Management was practically applied in the Franklin plant July, 1912, and it is quite apparent that both production and employment have been much more regular since that date than prior thereto. The smooth, broken line curves represent mean values and establish the general trend of the development. Here again is to be noted a matter of considerable interest. There is a marked change in the directions of the curves depicting mean values in July, 1916—in fact, there are two sets of such curves intersecting on the ordinate of that date. This indicates the change in variety of product and the commencement of new activity on a much more intensive scale. At times, prior and subsequent to July, 1916, production exceeded the mean and at other times did not equal such value, but the general growth followed closely the smooth accelerating curves. Prior to 1912, the jagged production line shows plainly the periodical, seasonal activity, usually commencing with July or August of a year, sometimes a little later, and extending to the following May or June. This was one of the peculiarities of the business at that time. Annually, production had to be built up virtually from the ground, only seriously to decrease some eight or ten months later, the crest of productivity usually coming in the spring of the year. This occurred year after year—an example of an industry based on repeat orders for few or many pieces at periodic intervals—one of the most difficult industries to conduct in an efficient and economical manner. After July, 1912, under the new-style management, while the annual periods of reduced production are still apparent, they are


Number of Workers
Car Production
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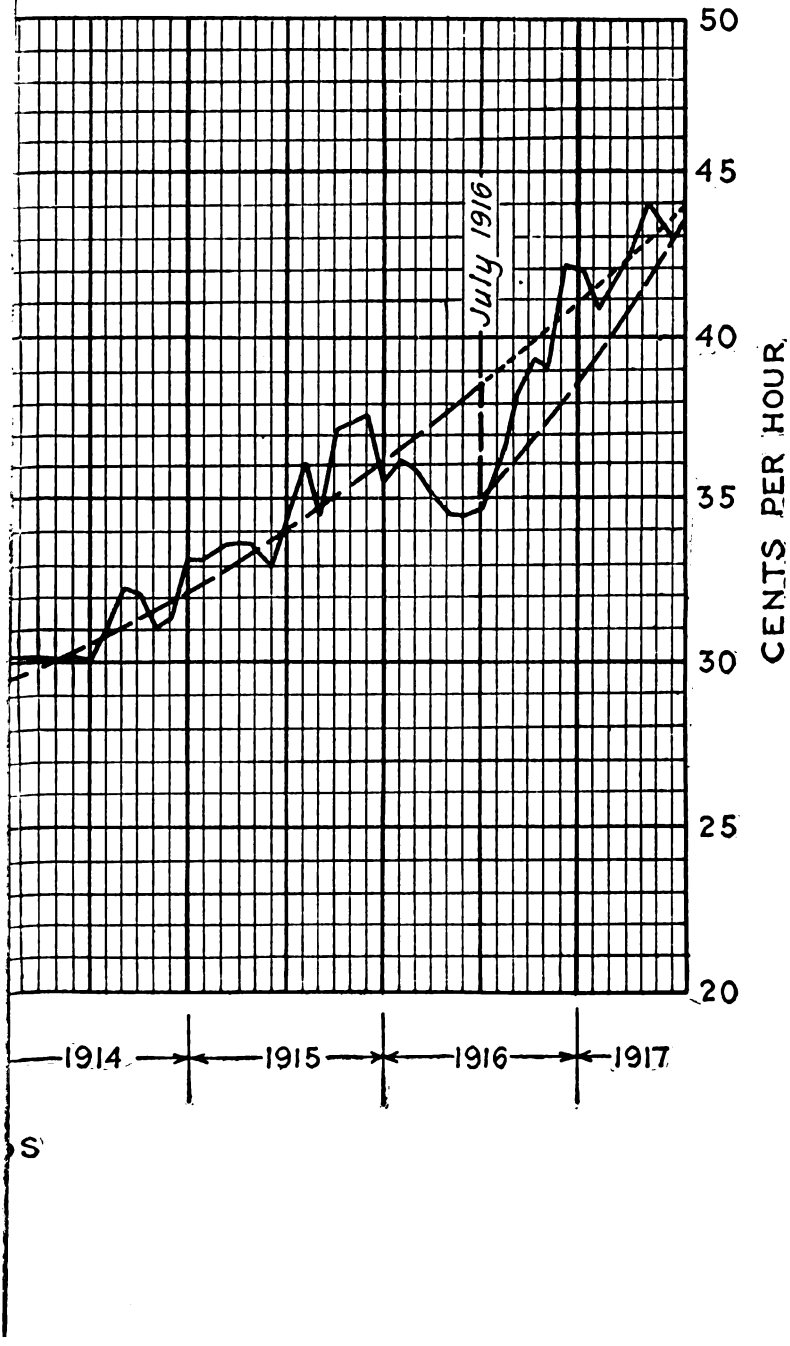
by no means as marked, nor do the crests of production form such decided peaks. Through Scientific Management, the industry was converted into one in which, though the repeat orders for few or many pieces still remained at more or less regular intervals, production showed no such accentuated variations as before, approaching, in fact, a condition of accelerating continuous activity. The employment of labor (number of workers employed) closely followed the same trend. This conversion of an industry from one of more or less intermittent operation to one of much more continuous activity is one of the most striking and gratifying of the results attained.

The graphs also reflect plainly the very radical change in product which occurred in 1916. The drop in productivity, reaching a low level in July of that year, marks the introduction of a complete new model of automobile, all previous work, tools and product being obsoleted at about that time. The condition occurring then, as shown by the production line, was very similar to that which periodically took place before the introduction of Scientific Management, and may be considered as marking the wind-up one one business and the beginning of another. While the production of the new model was picking up, it is quite evident that the number of men employed considerably exceeded the number which would have been required had the product continued to be similar to that brought out between July, 1912, and July, 1916. The regain in productivity was rapid and marked, for at the expiration of but six months output was increasing at a considerably faster rate than before the change in model. Employment, likewise, rapidly approached the indicated normal for the production, as the workers quickly

mastered the intricacies of the new operations. Scientific Management made possible the closing-up of a well-organized and efficiently conducted business and the building-up of a new and much more extensive one, employing a much larger force of workers, entailing new methods and operations, intensive training of workmen and a heavy investment in tools, fixtures and machines, all within a period of a few months. A record which is quite unique in the rapidity with which the changes were made and efficiency of the production maintained.

Chart II depicts the average hourly wage paid the workers from 1908 to 1917, and here again the steadying influence and regularity of increase is much more marked under Scientific Management than before. The workers had benefitted through increased wages prior to 1912, but the mean increase had not been marked and the irregularity of the wage line indicates no definiteness in trend. Increases in wages were apparently abrupt in the early days and were frequently followed by almost as great decreases. During the latter part of 1911 and the first few months of 1912 there had been a very decided increase in the average wage, followed by a quite appreciable drop, which reached the low point in July, 1912. After this date, under Scientific Management, the average wage received by the workers followed a regular rate of increase very much more closely, until the advent of the new variety of product, July, 1916. With the introduction of this radically new model, with new process of manufacture, etc., a considerable drop in average wage is indicated. This is but natural and should be anticipated, for the new men—many additional hands were taken on during this period—on new processes, etc., could not be as


50
45
40
35
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25
20
July 1916
CENTS PER HOUR
1914
1915
1916
1917

skillful as the trained men working on the production of the older and more familiar variety of product. However, the drop in average wage was of but short duration, and as the men became skilled in their work their average wages increased rapidly, and within a period of a year were fully as high as could have been expected and hoped for under former conditions. Though there were periods in which the average wage seems to have been somewhat abnormal, and during others the average wage received by the workers was below the mean values shown by the smooth curves, the general drift of the wage curves shows a substantial and steadily accelerated increase in average wage, broken only by the drop of July, 1916. This result, attained under and by virtue of Scientific Management, is naturally that in which the workers are most interested, but any such increase in average wage—an increase of 60 per cent. in five years—would be quite impossible of realization if it were not for the fact that the workers became more and more efficient under the new management.

This increase in the efficiency of the men is depicted on Chart III, which shows the decrease in the number of hours required for the production of a car. The smooth, broken line curves indicate the trend of reduction in the number of producing hours and draws attention to two important points: first, the very marked reduction in the number of hours required to produce a car immediately following the introduction of Scientific Management; and, second, in the latter half of 1916 and the beginning of 1917, the decreased relative efficiency of the workers, due to the fact that they had not yet attained the same degree of proficiency in operations on the new model car as had been developed on

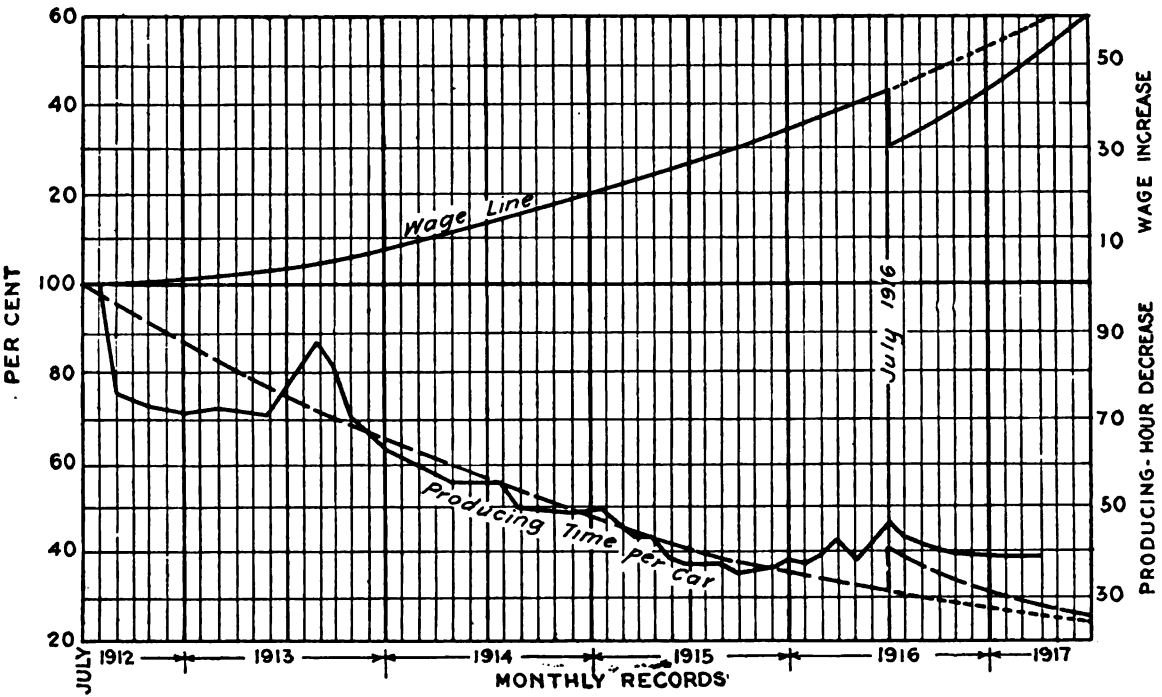

CHART III. PRODUCTION TIME AND HOURLY RATE OF PAY

the more familiar types through 1914 and 1915. This decrease in efficiency was but temporary, however, as evidenced by the fact that the broken line curve depicting the trend of reduction since July, 1916, rapidly approaches the dotted line continuation of the trend curve prior to that date. Another interesting point brought out is that the various peaks on the actual producing-hour line invariably mark periods of reduced productivity, showing that the best results are obtainable when the shops are busily engaged in production. The smooth wage curves shown on Chart III are similar to the broken line wage curves on Chart II—the scale differs, that is all—and it will be observed that there is a strong resemblance between these curves and the smooth, broken line producing-hour curves, indicating that average wages increased at very nearly the same rate as did the efficiency of the workers, measured by the decrease in the number of producing hours taken to complete a car.

How the organization can pay the increased wages on account of the decreased time required for production is shown by Chart IV. This latter illustration shows the general decrease in production cost per car made possible through the increased efficiency of the workers under the new management, with its improved methods, etc. The cost curves are not dissimilar from the producing-hour curves, the peaks occurring, as before, in periods of reduced productivity. The very marked increase in cost of car in 1916, when all former parts were obsoleted and a brand new model constructed, with new jigs and fixtures, new machinery and changed operations, is very apparent. This change in product represented a very considerable investment on the part of the organization, during which there was

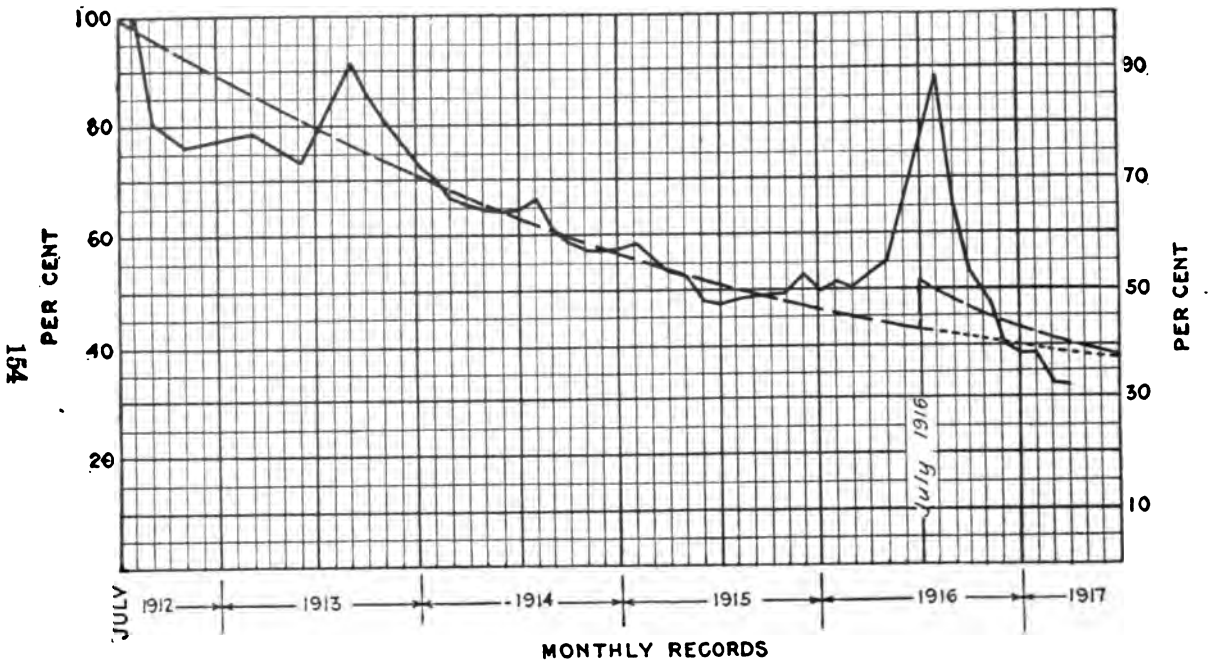

CHART IV. PRODUCTION COST PER CAR

no equivalent reduction in wages, although there was of necessity a reduction in the efficiency of the workers, as reflected by the relatively slight drop in average wage, on account of the new character of the work. However, by the end of 1916, the car cost had dropped to that depicted by the broken line cost curve, and by April of 1917 the production cost per car was materially reduced, notwithstanding the fact that at the same time there had been marked increases in average wage.

The benefits accruing to the workers under Scientific Management are strikingly and concretely shown by the accelerating wage curve on Chart II. Average wages have been steadily and materially increased. This is undoubtedly what is most desired by the workers, but it is only possible of continuance when the workers continue to become more valuable to the organization. The curve on Chart II indicates, then, not only the increase in average wage, but also the increased value of the workers. This increased value may be due to a variety of reasons: increased efficiency, greater knowledge, etc. In fact, all the factors which are considered in figuring the increase in the base rates of workers, as explained in Chapter VI, are reflected by the average wage curve. Chart IV depicts the concrete benefits realized by the organization through the introduction of Scientific Management, and may be summarized as reduced manufacturing costs—the main object of production management.

The main, and usually the only, object of *manufacturing* is to make a *profit*, and in order to do so the manufacturer must sell his product for more than it costs him to build and market it. That is, there should be a *margin* between his production cost and his selling

price sufficient to cover all selling expenses, etc., and to leave a balance for profit. Quite obviously, such margin is dependent upon two considerations, or factors, the production cost of the product and its selling price, and of these two factors only production cost can be affected by the production management. Any reduction in production cost—such as has occurred in the Franklin plant—is then a direct "benefit," quite irrespective of whether the manufacturer succeeds in marketing his product so as to show a profit or not, inasmuch as it increases the margin.

Reduction in production cost, disregarding the expenses of material cost and burden, may be secured in but two ways: by a reduction in labor cost or by an increase in the efficiency of the workers. If secured through the latter method, it stamps the production management as efficient and the workers as loyal, progressive and entitled to reward in the way of increase in wages. The only equitable increase in wages would be such that the "benefit" accruing to the worker, his increased pay, is proportional to that enjoyed by the company through the workers' industry—*i. e.*, the total benefit derived should be apportioned equitably between the company and the workers in direct proportion to their respective investments in the business of manufacturing, quite aside from the question of profit derived by the company in marketing the product.

The investment made by the company consists of the production cost of the product (the sum of the labor cost, material cost and burden), while that made by the workers is the labor cost (the product of the producing hours by the average hourly rate of pay). An equitable division of any benefit realized would then be governed by the ratio of the company's investment (C)

to the workers' investment (L). A constancy—over a period of years—in the value of such ratio, furthermore, would reflect uniformity in the fairness of division of benefit and mark the management as exceptionally efficient—provided, of course, no unusual outside influences affected the cost of materials and there was no radical change in product.

It is true that three important outlays are represented by the company's investment while there is but one in the workers' contribution, but there is normally an intimate relationship between all of these factors. The cost of materials may vary, increasing or decreasing the company's investment. This may be partly through manipulation, but in the long run it is a reflection of the value of labor, as normal fluctuations are almost entirely the effect of increased or decreased cost in the handling of the material. This is particularly true in the case of variations in the average cost of the several staple materials entering into the construction of an automobile. That is, when the average cost of materials increases, the value of labor also generally increases. Even in the case of elevation of material prices through manipulation, the value of labor should also increase to some extent, on account of its increased responsibility through working with more costly materials. Burden represents a cash investment and is dependent, therefore, upon the value of money, as is likewise the value of labor. With the three major components of the company's investment all materially affected (under normal conditions) by the value of labor, no very appreciable variation in the equitable division of "benefit" between the company and the workers should take place, unless there be a radical change in operating conditions, such as a very heavy

investment by the company in the way of expansion, a radical change in the product manufactured, or a marked increase in the cost of materials, created by an unexpected heavy foreign demand or intensive and prolonged manipulation. The effect of such radical alterations in normal conditions would simply raise or lower the value of the "equity ratio," which would then remain fairly constant while the new conditions existed.

There is one other economic consideration which deserves mention before investigating the position of the production management of the H. H. Franklin Manufacturing Company from the viewpoint of equity in the division of "benefit," and that is the effect of an increased investment on the part of either the company or the workers. In any cooperative industry, such as a manufacturing enterprise conducted on equitable lines, an increase in the investment of either Capital or Labor, whether it be for the purpose of increasing production, enlarging the field of operation or tiding over a critical period, will benefit the industry as a whole—the party not making the investment as well as the party making it. The party which does not make the investment, risking nothing, is then benefited to a greater extent than the party making the actual investment. Whenever the equity ratio $C:L$ is increased, then, the workers are benefited to a greater extent than is the manufacturer, and when the ratio $C:L$ is decreased in value, the manufacturer derives the greater benefit.

Chart V illustrates the percentages of such monthly ratios, calculated from the actual values given on Charts II, III and IV. The individual monthly ratios from July, 1912, to April, 1916—a period in which there was no radical change in product—differ but slightly

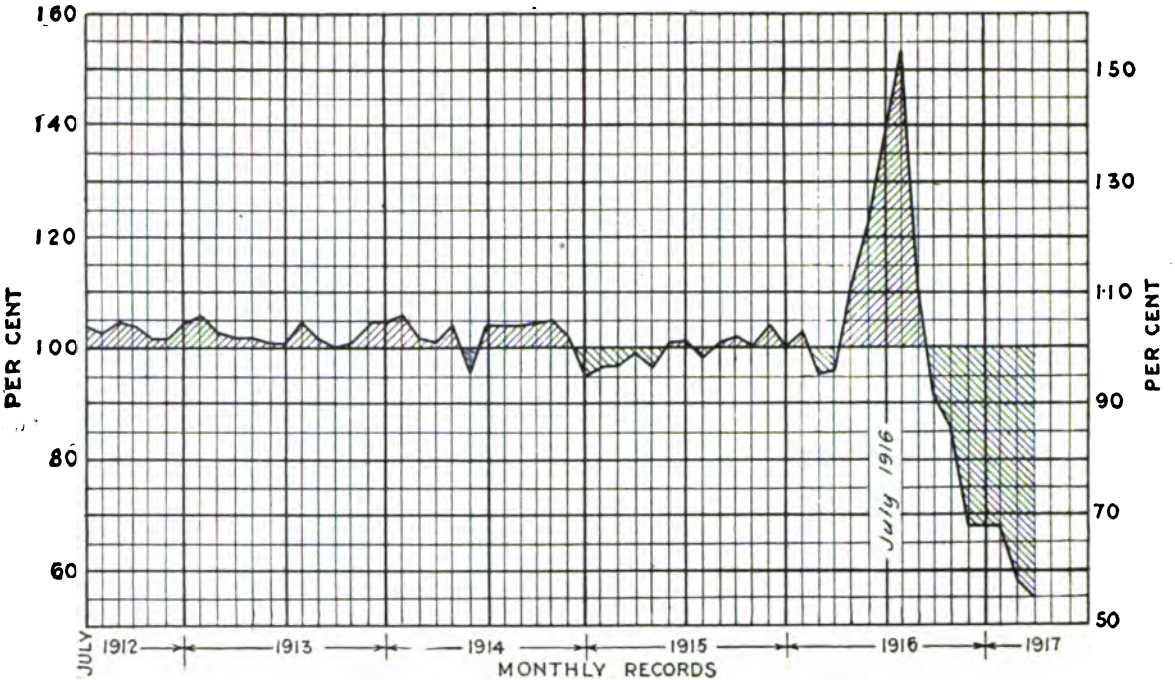

CHART V. PROPORTIONAL DIVISION OF BENEFITS

from the 100 per cent. taken as a basis of comparison. During this period the workers were, as a rule, favored slightly more than the organization, but the variation, one way or the other, was so slight that the division of the benefits between the organization (management) and workers is really remarkable in its uniformity. The fairness of the division on the workers' side is evidenced unquestionably by the freedom from all labor trouble since the introduction of Scientific Management and by the steady increase in average wage, while on the part of the management it is as strongly shown by the steady increase in volume of business. Contentment on the part of the worker and growth on the part of the industry could occur simultaneously only if the benefits realized were equitably divided.

In 1916, however, it will be seen that there was a very sharp and decided peak in the "benefit" line at the time of the radical change in product, indicating that the workers benefited far more than did the organization. This could not be avoided, for while such reorganization was being made it would have been manifestly unfair to reduce the wages paid to the workers sufficiently to enable the organization to make the extensive changes without a heavy investment. To have so evaded this outlay, had it been possible, would have been a case of exploiting the workers in the interests of the management. This would have been contrary to the principles of Scientific Management and to justice. However, having made the heavy investment, the organization was entitled to all such benefits as it could legitimately claim. It is interesting to note, therefore, that the Franklin Company did actually secure such legitimate benefits, as evidenced by the benefit line of Chart V falling below the 100 per cent. equity

line after the period of heavy investment in 1916.

Upon reimbursement to the organization for its heavy cash investment entailed in the very material expansion made in 1916 by the legitimately increased benefits depicted by the low value of the benefit line, the division of benefit again approaches an "equity ratio," but one which, if the expansion has been a wise one, is considerably below the former 100 per cent. equity line. This alteration in equity ratio is the result of a reduced proportional investment on the part of the organization made possible through increased manufacturing facilities, an increased output, and the employment of more workers. In other words, in the larger organization the workers control a proportionally increased interest in the business, so that the equity ratio $C:L$ is reduced.

One of the strongest endorsements of Taylor System in Franklin Management is that the radical reorganization of the business, whereby the output of the plant was increased some threefold, was carried on while and during the recognition of the workers' industry in the way of a continually increasing average wage. Except for the slight and temporary drop in average wage coincident with the much more marked increased cost of production in 1916, the workers have received higher and higher wages in recognition of their increasing industry and growing efficiency. These rewards were made possible even during the period of reorganization by the new system of management, and they continued through the period in which the organization reaped the somewhat increased benefits.

The five charts presented illustrate in a striking manner the benefits which have accrued to both the organization and the workers. Both branches of the industry

have gained much under the Taylor System as applied to the Franklin shops. The benefits have been mutual —a flourishing and healthy industry has been built up on the principle of justice and equity—and possibly one of the most remarkable developments to this end has been the derivation of the empirical formula by which the hourly rate paid the workers is established. When it is remembered that the increased cost of living, the value of greater and more extensive knowledge on the part of the worker, his loyalty, as evidenced by his years of continuous service, his efficiency, recognized by the payment of premiums, penalties imposed for spoiled work, absences and tardiness in reporting for work, etc., etc., have all been taken into consideration and valued in establishing the base rate of pay for each worker, then some idea of the efficiency and remarkable resourcefulness of the Taylor System in Franklin Management may be realized.

Doctor Taylor's four fundamental principles of Scientific Management have really been applied throughout the whole Franklin organization. The science is most highly developed in the factory, as is naturally the principle of training and selection of workmen, but the cooperative features and the equitable division of work and responsibility, without which neither the science nor trained men alone could accomplish the desired results, are found in all departments of the organization, from the highest to the lowest. No small credit for the wonderful results obtained is due to the hearty cooperation and loyal backing of the executive heads, the unqualified support of the financial division of the Company, the cooperation of the efficient sales department and the splendid spirit which permeates all branches.

APPENDIXES

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Appendix I

WAGE RATES IN THE FRANKLIN SHOPS

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FUNDAMENTAL BASE RATE

	Process Class of Work		Type and Make of Machine	Process Credits (*N*)	Total Credits	Base Rate 1905 (*B*)
A	SPINDLE MACH.	1.	Drills	¼		
			Single gang, Multiple, radial			.20
		2.	Tapping machine	½	¾	
B	LATHE	1.	Engine Lathe			
			Bore, turn, face, thread cutting	¼		.25
		2.	Lo-Swing	¼		
		3.	Turret	¼		
			Fox or Gisholt			
		4.	Jones and Lamson	½	1¼	.25
C	MILLING MACH.	1.	Power	½		.25
		2.	Hand	¼	¾	.20
D	AUTOMATICS	a.	BAR WORK			
			1. Cleveland	¾		.25
			2. Acme			
			3. Gridley			
			4. Brown & Sharpe			
	SEMI-AUTOMATICS	b.	Potter & Johnson			
			Faye	¼	1	
E	HAND SCREW	1.	Warner & Swasey	¼		.225
		2.	Pratt & Whitney	¼	½	.225
F	PRECISION GRINDING	1.	EXTERNAL			
			Landis			
			Norton	½		.25
			Brown & Sharpe			
			Universal			
		2.	INTERNAL	½		.25
			Heald			
			Bryant			
		3.	SURFACE	½		.25
			Heald			
			Blanchard			
			Diamond		1½	
G	GEAR CUTTERS	1.	Hobbers	¼		.25
			Barber & Coleman			
			Gould & Eberhart			
		2.	Shapers	¼		
			Fellows			
		3.	Millers			
			Brown & Sharpe			
		4.	Generators	¼		
			Gleason		1	
H	MISCELLANEOUS	1.	Planer or Shaper	¼		
		2.	Profiler	¼		
		3.	Boring Mills	¼		.25
			a. Horizontal			
			b. Vertical			
		4.	Punch Press	¼		.225
		5.	Use Micrometers and read blue prints	¼	1¼	

Process Class of Work	Process Credits (*N*)	Total Credits	Base Rate 1905 (*B*)
A Master Trimmer.			
Design and pattern drafting	¼		
Pattern making and lay-out	¼		
Cut and make up fittings for experimental jobs	¼		
Repair work, bodies, tops, slip covers	¼	(1)	
Requires all around man			.26
B Stock Cutter.			
Inspect and select stock	¼		
Lay-out for economy	¼		
Accuracy—No spoilage	¼		
Speed—Fast work	¼		
Leather cutter			.26
Electric machine cutter			.26
Buckram cutter		(1)	.26
C Body Trimmer.			
Closed car trim			.30
Open body trim	½		.26
Cushion build stuff by hand			.25
Cushion build stuff by press	¼		.22
Door trim			.20
Sewing machine			.19
Paste			.20
Inspect and select stock	¼	(1)	
D Seat Cover.			
Fit and adjust	½		
Sewing machine	¼		
Lay-out and cut stock	¼		
Seat cover maker			.258
Seat cover helper			.22
Sewing machine		(1)	.19
E Top Maker.			
Covering and fitting curtains, etc.	¼		
Setting up bows and covering bows	¼		
Sewing machine	¼		
Lay-out and cut stock	¼		
Build top complete			.26
Cover bows and set-up			.19
Sewing Machine		(1)	.19

Work and Department. (No Process Credits Yet Established.)	Base Rate 1905 (*B*)
CASE HARDENING.	
Heat treaters	.225
Brazer	.245
General labor	.175
TOOL DEPARTMENT.	
Toolmakers	.325
Oilers and beltmen	.20
WOOD SHOP.	
Bench men	.22
Machine men	.24
PAINT SHOP.	
Air brush	.235
Finishers	.25
Putty and sand	.15
Stripers	.25
Paint mixers	.20
Monogram men	.30
FINAL ASSEMBLY.	
Sub-assembly	.23
PATTERN.	
Metal	.275
Wood	.30
REPAIR DEPARTMENT.	
Repairmen	.275
Wash room attendants	.21
HEAT AND POWER.	
Day fireman	.165
Night fireman	.20
INSPECTION.	
Finished parts	.27
Raw material	.275
MILLWRIGHT.	
Millwrights	.235
Millwrights' helpers	.185
Electricians	.25
Yard men	.15
Gate men	.15
Night watchmen	.125
STORES.	
Raw stock	.175
Finished stock	.175
FIRST AID.	
Janitors	.15
Plumbers	.20
STOCK MOVERS.	
Move men	.165
Elevator men	.15

RELATIVE COST OF LIVING

In order to determine the relative cost of living since 1905. the four principal elements—food, clothing, fuel, and shelter—were taken into consideration.

The territory involved was the locality contiguous to the plant of the H. H. Franklin Manufacturing Co., Syracuse, N. Y., in which territory the larger part of the workers resided.

After considerable study and tabulation the average workingman's family was taken as consisting of himself, his wife, and three children—two boys, aged fifteen and nine respectively, and one girl, aged seven.

The menu of a large number of families was averaged for three meals each day at four periods of the year—spring, summer, fall, and winter.

A study was made of the clothing each of these families desired for proper warmth, protection, and consistent appearance.

The fuel considerations were those for warming the dwelling in which they lived and also for cooking their food.

The typical home was considered, its assessed valuation, and the annual taxation, assuming that the workingman owns his own home. This taxation was considered as the index of rentals.

The investigations were made to a great degree of thoroughness and accuracy. All possible factors affecting the cost of living were investigated, the following summary was developed, and the percentage of increase in costs for the years 1915 and 1916 over that of 1905 was determined.

SUMMARY OF DAILY COSTS BASED ON 300 WORKING DAYS PER YEAR.

ITEM	1905	1915	1916	NOTES
Food	$1.34	$1.776	$1.994	Average or normal menus on four typical mid-season days.
Clothing	.70	.77	.935	Average cost for principal articles for family.
Fuel	.26	.255	.28	Average cost for entire family.
Shelter	.32	.60	.64	Four times the daily cost for taxes.
Total	2.62	3.40	3.849	The cost per work day for these listed items for the family.
Difference	....	.78	1.229	Direct subtraction of 1905 costs from 1915 and 1916 costs respectively.
PER CENT. OF INCREASE	....	29.8	46.8	Calculated using 1905 as the base year.

COMPARATIVE STATEMENT OF COST AND EARNINGS.

PROBLEM—Cost of Operation No. 14, Finish Grind Bearings on M-9 Crank Shaft No. 21158. Before we began Rating Method application, using the same overhead rate as for the highest week of recent earning. Conditions must be the same on the crank now and then for complete comparison. Use Standard Cost Formula accepted by the Accounting Department. Use the same operator, H. K., No. 532. Time taken from actual cards from him.

H. K.....No. 532 Dates Chosen	Before First Rating Apr. 21-2-3-4-5-6-7	Since Last Rating Sept. 19-20-1-3-25	Per Cent. Increase	Per Cent. Decrease
Rate per hour = r.....	$.355	$.535	50	..
Overhead per hr. = R.....	.400	.510	27.5	..
Prem. time allowed per piece.....	104 min.	104 min.	0	0
Lot size.....	35 min.	35 min.	0	0
Time allowed, per lot.....	60.6 hrs.	60.6 hrs.	0	0
Time taken, per lot.....	35.6 hrs.	24.6 hrs.	..	30.9
Time saved, per lot.....	25.0 hrs.	36.0 hrs.	44	..
Prem. hrs. earned, per lot.....	12.5 hrs.	18.0 hrs.	44	..
Per Cent. of Prem. hr. earned per lot = e.....	35 1-10%	73 2-10%	108.6	..
Time taken per crank = t.....	1.017 hrs.	.7029 hrs.	..	30.9
Cost per crank X = [r(1+e)+R]t..... =	[0.355 (1.351)+0.51] 1.017 $1.0064	[0.535 (1.732)+0.51] 0.7029 $1.0097	.. 0.31	.. ..
WEEKLY EARNINGS STD.....	$23.36	$44.38	90	..

From this table it may be seen that the increase in the cost of living since 1905 up to and including 1915, measured on the basis of the principal requirements of the typical family, was 29.8 per cent., and that since 1905 to 1916 was 46.8 per cent.

RECALCULATION OF A WORKER'S RATING

In order to exemplify the manner in which a worker's rating is recalculated four times a year, a typical case, that of Mr. H. B., Clock No. 508, in the Machine Shop Department, is given.

On September 18, 1916, the Employment Superintendent sent to Mr. H. B. the following letter:

"We are about to recalculate your rating. In checking your record we find it differs from your first rating as follows:

Factor	Explanation	Your Previous Rating		Your Record for This Last Period	
	Per cent. of	Yours	Std.	Yours	Std.
e	Premium earnings.....	19.4	33.3	11	33.3
Pa.	Absence.....	5.8	0	2	0
Pd.	Day work.....	56	10	54	10
Pl.	Suspended for no work.....	0	0	0	0
S	Spoilage.....	0	0	0	0
M	No. of major processes.....	2	2	2	2
y	Years of service.....	4.5	5	4.75	5
C	Conduct and cooperation.....	1	1	1	1

"This decrease in premium earnings and decrease in day work offsets your decrease in absences and your increase in years of service, and will tend to lower your rate proportionately.

"However, there will be no change in your rate until you have advised us of the causes which have made this change in your record and we have made complete investigation of the facts.

"Please gather all data you have to show concerning the conditions which have affected your record and arrange to see me on September 20, at 9:00 A. M."

On the day specified Mr. H. B., No. 508, operating a surface grinding machine, reported:

"The Time Study Department set a rate of 120 pieces per hour on my machine and it is the maximum capacity. It is impossible to run the machine at a greater capacity, as it stops when this is done. The belt is now so tight that it pulls apart at the lacing. For another thing, the Inspector that worked in conjunction with the Time Study Department did not show me the right way to do the job, consequently a majority of the pieces have been returned to me for correction. In order to do the extra work on the pieces I have to use more time and feel that the present rate should be reset.

"My job card does not show when I am on premium work and when not. Even so, I could not make premium speed, as the machine is now loaded to its full capacity. Another thing, delay is caused by poor fixtures. The magnetic chuck allows the part to whirl around and cut the wheel instead of the wheel cutting the part. This causes the redressing of the wheel, which takes from five to seven minutes each time. A

new fixture which increased the output wonderfully was furnished, but the work it turned out was not up to the Inspector's qualifications and I had to discard it.

"Another trouble has been lack of M-24 grinding wheels. I have had to get along as best I could with two wheels for two months. The Assistant Foreman on that floor tried to locate some in the Stores Stock Room but was unable to find any." [At this point the Employment Superintendent sent a man into the Stores Stock Room, who found seventeen new M-24 wheels which had been received three months earlier.] "Furthermore" [Mr. B. continued], "my machine needs a thorough overhauling. But it is impossible to do this, as the machine is being worked night and day. Outside of the Time Study being wrong, my greatest trouble is in getting supplies and not finding out whether they are available or not and, if so, where they are located."

The Employment Superintendent informed Mr. H. B. that he would carefully check these causes of delay and re-rate him on the result of his investigation. In accordance with that promise he made a number of investigations and found that the claims made by Mr. H. B. were substantially correct. The M-24 grinding wheels had been replaced by wheels marked CM-24 and a new clerk did not know of the change. On October 8, therefore, the Employment Superintendent again summoned Mr. H. B. and was informed that repairs were being made on the machine in question. The Employment Superintendent closed the matter by stating:

"It is hard to estimate your rate adjustment, but since you did not report any trouble prior to our for-

mer interview we are going to hold your rate at 37 cents up to December 1. You will have until then to make your record. The conditions are now very good, and you think your chances are better. If you are satisfied, we will keep your present rate until December 1. In the meantime, if anything should occur to hurt your rate you must notify your Foreman at once and also let me know. The sooner it is corrected the better."

STATEMENTS BY EMPLOYEES

To substantiate the arguments that the workers are thoroughly in accord with the method of payment that the Franklin Company has effected, the Employment Superintendent on November 1, 1916, asked some of them the question, "What changes in your habits, mode of living, etc., have occurred since you have been master of your own pay?" The replies were practically similar in all cases. For brevity, two of the replies only have been settled as typical and are given herewith.

Mr. K., No. 532, stated as follows:

"(1) HEALTH: Have lost a little in weight, but you know my hay-fever pulls me down every year from August to October. However, outside of that, I am feeling fine and am gaining back my weight.

(2) HYGIENE: More careful about my personal care.

(3) HABITS: I think much more than I used to about keeping physically fit for the job.

(4) FOOD: Although my grocery bills are about the same as before, we have more luxuries and wider variety of things to eat. Sometimes if company comes in, we get some ice-cream, never used to feel we could be so hospitable.

(5) CLOTHES: No! Haven't gone in for any yet, but I am going to get some new things. I want to know I can pay cash for them. My wife has just bought some new things.

(6) SAVING: My little old bank account is growing and it's fun to watch it. We think we are getting somewhere now.

(7) PLEASURE: Bought a new piano, getting that paid for fast.

(8) INTEREST IN WORK: It's a real pleasure to work, it's fun. We think more about our work. We get on the job a few minutes early, we stick until the horn blows, we used to take time off now and then, although never lost much, but now we think twice. Had a chance to work on the polls, but passed it up because didn't want to hurt my efficiency in any way. There was a 'good' piece of change in it, too!"

Mr. B., No. 533, made the following statement:

"(1) HEALTH: I have increased a little in weight; I have felt better in the last six months than ever before.

(2) HYGIENE: My wife needed dental work, had been put off because of the expense, she had it done lately. I paid half down in cash and could have paid it all; you know what dentists' bills are.

(3) HABITS: I'm more regular in my hours of sleep. Before when my wife and I went out, neither one of us thought so much about the time we turned in; now she says, come along—you know you want to keep fit for tomorrow, and I find I am more willing to listen.

(4) FOOD: When we worked overtime before, we used to go over to the saloon, get a beer and a sandwich, come back, feeling punk; now we go to the lunch room, get some steak, etc., price 15 to 20 cents, cut out the beer and come back feeling fine. At home, also, we have more luxuries.

(5) CLOTHES: I haven't put anything extra into clothes so far, but I'm not keen for a lot of swell duds;

I like to see my wife well dressed and she has had a new coat this fall.

(6) SAVING: I bought an endowment policy recently; heretofore I never thought I could save it, now, although it costs me at my age $22 for a quarter, I'm going to be prepared for my later days. When I used to go out with only three or four dollars in my pocket and blow it all because it wasn't much; now I spend only what will carry us through. When you have got $50 you feel like making it $100.

(7) PLEASURE: We seem to get more pleasure out of life, not that we are blowing any money foolishly, but I mean we get more enjoyment out of being alive.

(8) INTEREST IN WORK, ATTENDANCE, ETC.: It seems more like a game than work. We took you at your word and we have gone after this for all it's worth. We are not suffering any, nor do we find any breach of our confidence in you."

Mr. H.: Are you willing that I report these statements to the Production Manager?

Mr. B.: Yes! I am! I'm willing he should know about them, for I'm certainly satisfied to have a hand in making my own rate of pay.

Appendix II

EXAMPLES IN APPLICATION OF SCIENTIFIC MANAGEMENT

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EXAMPLES IN APPLICATION OF SCIENTIFIC MANAGEMENT

Three main groups of manufacturing activity for which methods of Scientific Management have proved highly efficient may be classified as Repair Shops, Small Parts Factories and Plants with Uniform Manufacture. Each one of these mechanical enterprises offers distinct possibilities of installing the Taylor principles — differing somewhat in application, it is true, but nevertheless the four fundamental principles expounded by Doctor Taylor.

Referring to the three broad classes of mechanical endeavor as: Enterprise No. 1—Repair Shop; Enterprise No. 2—The Small Parts Factory; and Enterprise No. 3—Plant with Uniform Manufacture; the scope of each will be briefly outlined before describing the system of Scientific Management best suited to its individual requirements.

Enterprise No. 1—Repair Shop

Chiefly for a "one line" article, such as the locomotive, car, or automobile, but which can be adapted with local modifications to any "jobshop" or small miscellaneous manufactory.

The fundamentals indicating this type of management are: Non-repeating orders on which a limited number of men broadly trained must do a variety of things; fixed equipment is used intermittently; time too lim-

ited or cost excessive for pre-planning; standards of a very limited kind.

Enterprise No. 2—The Small Parts Factory

Manufacturing staple articles for demand stock; the parts not gathered together in complicated assemblies or related previous to shipment.

The fundamentals indicating this type of management are: Repeat orders of nearly uniform size, but active at irregular intervals of time, upon which (as in Enterprise No. 1) a limited number of men must do a large variety of things; fixed equipment more uniformly burdened than in Enterprise No. 1, but still much of it inactive from time to time. Due to orders repeating, pre-planning can be somewhat highly developed and such costs can be absorbed on subsequent orders. A large percentage of equipment and activities can be standardized.

Enterprise No. 3—Plant with Uniform Manufacture

This can be typified by the continuous reproduction of staple articles in large quantities—the motor car, typesetting machines, typewriters, etc. The articles to consist of complicated assemblies made of a large variety of parts. Orders develop into pre-planned schedules which are practically recurring at uniform time intervals. Many men are required, each operating steadily on a small element of the work; fixed equipment is uniformly burdened; standards completely developed for all equipment and activities. The chief task in the management of this enterprise is that of co-ordination of a complex product.

Any one or all of the above enterprises may be included in the activities of one company.

To prevent misconception of some words which will be repeatedly used in the continuation of this subject, we will standardize them by definition.

CONTROL—To cause all work elements to follow out a prescribed plan of action.

ROUTING—To plan "where," "how," and "by whom" and in what standard time work shall be done.

SCHEDULING—To plan amount of work and when each element shall start.

DESPATCH—To meet the conditions of control by applying schedules to routing.

Control is entirely executive.

Despatching is executive, but subordinate to control.

Routing and *scheduling* are planning, but subordinate to control.

The persons in control are the general manager, works manager, production manager, superintendent, or other persons of similar executive position.

The routing division will contain those persons who analyze facilities for doing work, and who by studying the work to be done, plan for and locate all machines, tools, and fixtures. They will prescribe the path of the work over this equipment. They will specify the operation to be performed and the standard time in which to perform each operation. They will determine and establish all standards for machines and shop methods.

The schedules division will contain those persons who plan for the quantity and rate of output for the product. They will specify the date to start each unit of work at each station on the route as prescribed by the routing division. The standard time required for

elemental work at each station having been established by the routing division it is therefore needless to schedule a date to finish if a standard allowance time for movement of work between operations as provided has been established.

The despatch division will contain all persons whose duty it is to see that orders are issued, materials secured, tools provided, and all movements made which will cause the schedules to be carried out. This will involve those who prepare Control Boards, route sheets, assembly charts, job cards, stores issues, ticklers, and all similar standard forms, or paper. It will involve also the executives in direct charge of the materials, men and machines, as storekeepers, foremen, or bosses, inspectors, millwrights, transportation men and employees.

The above classification of duties differs in nearly every industry applying the Taylor principles of Scientific Management, and yet the results obtained in each uphold conclusively the value of these ideals. This fact alone should convince those who are interested that Scientific Management is not a "ready-to-wear" garment, but rather a fine system of "fitting" by which industries can be greatly improved in conduct as well as in appearance, yet retain their individuality. Just as a specially designed and fitted garment will reflect the ability of its tailor, so will the result of any application of Scientific Management reflect the ability of the person or persons chiefly responsible for its installation and conduct.

In the detailed statement of methods which follow we are presenting specific examples chiefly useful to illustrate the application of the Taylor principles of Scientific Management to the three broad classes of

enterprises mentioned previously—the repair shop, the small parts factory, and the plant with uniform manufacture.

The preparation of the organization and men and the establishment of essential shop practices will not be treated separately, but can be appreciated from these examples of actual practice.

ENTERPRISE NO. 1—THE REPAIR SHOP

The conditions in this shop previous to the installation of Scientific Management were as follows: The superintendent received orders from customers, either by communication or in person. The job was studied more or less thoroughly by the superintendent and shop foreman, who furnished an estimate of total cost and time of delivery of the finished order. They then endeavored to fulfill the conditions of their estimate.

The capabilities of the various workers, or the accessibility of materials and tools for a given job were known only in a general way. The combinations of elemental operations in each job usually varied from any others, although the elements were frequently similar or exactly the same. As no detail records of elemental operations were maintained, each new job required the personal attention of these head men to estimate the "over-all" cost and times. It then became their duty to give by word of mouth detailed instructions to their workers which would cause the result to coincide with the estimates given sometimes weeks before. The superintendent and foremen were practically walking encyclopedias as well as estimators, employers, instructors, disciplinarians and a thousand and one things which a supervisor is expected to be. Under the sightest pressure of work yet to be done, the estimates were hurriedly made, and usually failed by a large percentage. Customers' complaints were

common. Each complaint, however, received immediate attention by a rearrangement of the workers so as to favor the latest complainant.

Under this condition a large number of jobs would be in a partially completed state at the date of promised delivery. Once the job was started and partially completed, since there was no record of how much had been done except in the mind of the worker, if such work stopped and was again started it required another "over-all" estimate with even less time than that allowed for the first to tell the customer when the job would be completed. These answers were frequently given to the customer from the time a telephone receiver was taken down until it was hung up again. Several estimates given under this pressure were later tested as to their accuracy, from a study of the average times taken to do the work and the allowances made for interference with the work due to lack of materials and tools, the actual average time required to prepare these estimates was from two to three hours with the estimate still an approximation.

The shop charge per hour was a flat rate to all customers regardless of the training or ability of the workers on the job. The total labor billings for a month were frequently less than the labor cost. The difference was charged into the overhead expense. It is obvious that the workers' wages were seldom increased.

At times the shop would be full to overflowing with work and at other times very scarce of work, with a consequent extreme variation of the number of men employed, so that they were suspended and again employed without notice. The cause of this variation was chiefly the acceptance by the superintendent of any work which came his way, and promised dates

of deliveries arbitrarily given, usually according to the customer's wishes rather than in a time in which the work could be actually accomplished. Good workmen soon became scarce, and even the untrained and poor workers were irregular in attendance and careless in their work. The final results of the job were high charges for poor service, usually overdue in delivery.

The method planned to overcome this condition will indicate many other weaknesses which need not be here related.

THE REORGANIZATION

The first change was made in the supervising methods for the shop. The superintendent was freed from a great amount of clerical duty which was transferred to more efficient yet less costly assistants. This freed the superintendent for a broader view of his problem and enabled him to give intelligent action upon estimates.

The different classes of work which could be done in this shop were then studied, grouped according to a chart showing grouping of men according to their ability to perform classes of work in the shop, and standardized. The arrangement of the classes of work was in the order of the ability and training of the workers, *i.e.*, any worker in Class A could do work in any class below him, and so on down the list. This being standardized, the superintendent, foreman, or despatch boy could give out work of different classes to men out of the classes with equal facility. In case it was deemed advisable to give a man routed in a lower class of work a job routed to a higher class—*i.e.*, a workman in *G* transferred to *D*, it was necessary for

the superintendent or the foreman to approve of such transference for the one job only. If the upper transference of such a worker caused him to work in a class higher than his own more that 50 per cent. of the time, he was transferred to the upper class permanently.

Workers were then studied and encouraged to select the highest possible class in which they were reasonably sure that they would not receive criticism for lack of ability. They were then arranged in each class in the order of their ability and were rated and paid according to the positions which they held from the highest to the lowest in the class, and from the highest to the lowest class.

In writing an order for a job, the superintendent classified his order according to these classes, and the order was immediately delivered to the planning room.

The order should show the customer's name and order number, the estimated date of delivery of the finished job and a statement in paragraphs with symbols of each element of the job according to the standard classes. The estimated operation time required to perform each of the elemental operations, with an allowance time added to each of the operation times, should be noted on the margin of the order, this allowance time being the idle time of the job after each operation. The time for the first operation is added to the second, the second to the third, the third to the fourth, etc., until the total time required for the sum of the different operation is known in work hours. With the date of delivery of the job set, each operation can then be dated as to its time to start on a given hour and a given day. In case of change of final dates of delivery new dates for each of the elemental opera-

tions are readily set by any clerk without further estimating.

Coincident with the starting of this plan records were maintained of the actual time taken to do these operations in the shop. Soon a large library of information was obtained, and estimates are now made from these facts rather than from opinion.

The delivery of finished jobs on schedule time began to occur with marked regularity within a matter of only a few weeks after the plan was started.

After the order was written, as noted previously, it was sent to the planning room. The route file clerk immediately translated and wrote the order on a route sheet. He at the same time wrote a job card for each operation and symbolized it according to the class of work called for by the operation. The job card consisted of three copies; the face copy being a small coupon; the second copy an Inspector's and move ticket; the third copy a workman's job card.

The route file clerk also wrote the material stock issue for such materials as were specified in the order. He wrote the symbol and date for each operation on a long narrow schedule card which was then hung between hooks on a bulletin board. The spacing of writing on this card was the width of the small coupon of the job card. The coupon was punched with holes to hang on hooks, each covering a part of the schedule card on the bulletin board. When each job started, the coupon was hung on the hooks over the corresponding operation noted on the schedule card. Since the schedule cards, as well as the coupons, bore the date that each operation was to start, if the coupon was hung on the board over its corresponding place on the card, it was evident that the job had started. In case

an exposed date on a schedule card was behind the date on which the board was being inspected, this card date was not covered with a coupon, and it was evident that the job was behind schedule. The board was inspected each two hours in the day and all dates behind the current date were blue pencilled if they were not covered by a job coupon.

A mere glance at the bulletin board indicated at once to the superintendent any jobs that were weak and behind schedule, and he could take immediate constructive action with the minimum of his attention.

After the route sheet is written, a second copy is made on a heavy card, and the card is sent to the foreman in the shop as instructions for work.

The job cards are put in boxes in despatch racks, especially arranged as follows:

One box is prepared for each class of work, the bottom of which is divided into two compartments: one in the front for jobs that were ready to be worked upon; one in the back for jobs written and in process, but not yet ready to be worked upon. In the cover of each box, which is raised at right angles, are thin compartments, one for each man listed in that class of work, the arrangement in the order of their ability, *i.e.*, the boxes are arranged and classified strictly according to the classification chart.

After the route file clerk has written the job cards for a given job, they are sent to the despatch clerk, who puts the first operation job cards in the front compartment of the box representing the class of work to which it is routed. All other cards are placed in the rear compartment of the boxes representing the classes of work to which they are routed—*i.e.*, each order is subdivided by its job cards into the different

classes of work as standardized. When a workman is available in any one class, having finished a previous job, he hands in his card to the despatch clerk, who notes the classification under which the workman has been working, goes to the corresponding box, takes out the first job in the box and gives it to the worker.

All jobs in the front compartment of the boxes are arranged strictly according to their dates, and the job which the workman receives is obviously the one requiring first attention. Since this arrangement of job cards by dates is one of the fundamental elements in the despatch plans of all three enterprises, it will be essential that a complete understanding of this be grasped at this time.

When the above-mentioned workman finishes the job which he has and returns for more work in his class, the despatch clerk may find that there is no more work there standing. In this case he would give him the first job in the next lower class in which a job was standing. If any operation is urgent—*i.e.*, behind date, or a customer was waiting for a job, a red "lot urgent" tag is attached to that operation, and when a man rings out in a class above that in which the card is standing he is given this urgent job first, regardless of other work in his class, or nearer to his class.

Upon the foreman's receipt of the card copy of the route sheet, and the workman reporting to the job with his card, the foreman assists the man to start on the job, and from time to time inspects his work in process.

At the completion of each operation a floor inspector makes a careful inspection. He also makes a final inspection of the complete job.

Tools have been highly standardized for the different classes of work, and each worker is equipped with a standard set. Special tools are accessible, as are materials from stock rooms immediately adjacent.

At four o'clock each day the jobs ready to be worked on are inspected as to dates. If any are behind schedule, they are either marked with a "Back of Schedule" card or an "urgent" card, depending on their relative importance. The bulletin board is marked to correspond. Curves are plotted daily to show the number of operations behind schedule, the number of operations ahead of the shop and the percentage of operations of the shop which are behind schedule. These curves are posted in the superintendent's office, and are in general the regulator of the promised dates of delivery of new work. If his percentage of jobs "behind schedule" is very low, he will give earlier orders of deliveries on new jobs. If there are many ahead of the shop he will make later dates of delivery of new jobs. In this way, after a reasonable experience he is able to maintain a very equitable burden upon the shops.

RESULTS OF REORGANIZATION

The superintendent and chief estimator is never under a heavy pressure of executive work, and can meet customers and deal with them without interruption. He can retain their respect on account of better delivery dates of the finished jobs. His intelligence, as well as the combined intelligence of the shop, is accessible to all persons for common use, without interruption of the workers at their particular tasks.

Costs are based on estimates and are practically exact. Customers' complaints are seldom heard.

The peak load of burden, while not entirely removed, is much improved, and the change in the burden is gradual and can be anticipated. This allows for the taking care of workers in the shop, or in outside industries.

The lost time due to waiting for materials and tools, and particularly for instructions to the workers, has been eliminated. Consequently the income of the shop is now profit rather than net loss.

The workers have been materially benefited by this through a complete readjustment of their wages, with increases to an equitable amount.

The conditions of the shop with its certainty of instructions, regularity of orders, the lack of expression of violent opinions, have improved so materially that there is no comparison between the new and the old conditions.

The workmen appreciate being told specifically what they are to do, and being free from criticism in case the instructions fail.

The final result of the shop is, equitable charges for good services, generally rendered on the date due.

ENTERPRISE NO. 2—THE SMALL PARTS FACTORY

Unlike Enterprise No. 1, the manufacture of single parts, or small assemblies for stock, offers an opportunity for standardization due to the probability of recurring orders.

Sources of orders for this shop are: First, the anticipation of the engineers at the time of design as to the probability of wear or of breakage; second, customers or dealers; and third, quick orders from the local car repair shop.

Since any of these sources, or all, may furnish orders simultaneously for the same part, it is important that some central place be provided for the accumulation of individual orders, and guided by this accumulation the issue of a single order of standard size for economical production to the manufacturing shop.

The practical medium for this is the controlling balance of stores ledger. The ledger is provided for single entries under the four following headings: First, On Order; second, On Hand; third, Apportioned; fourth, Available. As the individual orders are received they are at once entered in the column "Apportioned," and subtracted from the column "Available." If there is no "Available" at the time of such entry a manufacturing order is written for the standard quantity, which quantity is posted in the column "Available" and "On Order." The amount apportioned is then subtracted from the "Available" column. From this time

on if the "Available" falls below a predetermined amount, as recorded on the balance sheet, a new order is placed in the same manner. After the order has been in process and is closed by receipt of material into finished stock, the amount of parts is added to the "On Hand" column and subtracted from "On Order" column. When shipment is made, amount is subtracted from "Apportioned" column and "On Hand" column. This completes the ledger transaction.

The manufacturing order is written in three copies and is sent over a predetermined routing as standardized and printed on the order. The date to finish is entered on the order. The order path is as follows: First, the routing department for preparation of route sheet, tools, patterns, time studies; second, a requisition of materials calling for purchase order; third, preparation of the route file; fourth, starting of the material into the shop; fifth, closing order; sixth, compiling cost.

When the order is received by the routing department the master mechanic prepares a route sheet which shows the different operations to be performed on the part, tools and machine for each operation, unit material and standard time for each operation. He determines the standard lot size and establishes and enters the routing time for the lot from the receipt of raw material to finished stock. This latter information is used by the route file clerk to date each operation order for time due on the machine.

After the unit material is specified the amount for the lot is determined and recorded on stores issue. The stores issue is passed over a raw stores ledger in the identical manner of the manufacturing order.

A standard time for securing each kind of material is established by the purchasing agent. It is arranged in such classes as bar stock, forgings, aluminum castings, sheet aluminum, grey iron castings, etc. The standard time specified for each article is limited by the ability of the purchasing agent regularly to bargain, buy and deliver to stores.

A standard time is provided for the material to pass through the inspectors and into stock.

To prepare the route file, a job card is written for each operation. The information on the job card is: part drawing number, lot number, operation number, name of part, name of operation, machine for the operation considered and the machine for the succeeding operation.

The stores issue is prepared to show part drawing number, lot number, part name, unit material, total material for lot, name of material, date due to issue to shop, machines for operation considered, and certain other essential entries, as—when order is apportioned or issued.

A stock tag is written which accompanies the material through all operations; the tag shows part name, drawing number, lot number, and the machines for the complete routing of the lot. The tag is an identification of the material and subsequent parts, and is never removed from the lot.

The different papers are dated as follows: A straight line calendar is used. This shows dates only of working days for the year. The interval of spacing for each date is constant. Another scale is divided into the same interval, reading from zero up to a total number of days as the longest time from the receipt of the customer's order to the delivery of finished parts

on shipment. In this particular shop 150 days is approximately the limit. The zero of the number scale is set to the date of part due in stock as finished, and from the route sheets the days are read off when each operation must start for the particular lot.

The standards involved in the above are routing to manufacturing orders, lot size, purchasing time, stores' time, producing time, and allowance time for the lot to move from one operation to the next, fixtures, tools and instructions.

After the route file is prepared and a tickler copy of the manufacturing order calls for the starting of a job, the following procedure is carried out: Assuming that the material has been received and is in stores and the receiving ticket has been recorded at the ledger for that material, the combined stores issue, move ticket, and job cards are sent to the stock room. The stock is delivered, receipted for by the shop representative and the issue returned to the stock room. From here it is distributed, one copy to the planning department showing the issue of the material, another copy through the stores ledger and into costs. The job cards which accompany the stores issue and material to the shop are distributed in the job card racks under the following plan:

We will consider the machines of one group:

Assume this to be turret lathe with a symbol LT, and nine machines in this group numbered from 1 to 9, *i.e.*, No. 1LT, is No. 1 Turret Lathe, 2LT is No. 2 Turret Lathe, etc.

All of these machines are maintained in perfect condition, and all work is interchangeable.

When an operation is planned to go on a turret lathe the symbol LT is shown on the route sheet and is car-

ried forward to all job cards. There are also jobs coming to these machines from other route sheets. The jobs having been dated from the different route sheets as to the time due on the machines, they can be arranged in the despatch rack box in the order of dates and will go on to the machines in their proper order. In a vertical cover of the box are card holders, one for each of the nine machines. When a job is given out from the main group of jobs to an individual machine, the job card is time stamped and one copy given to the individual worker, who takes it to his machine. The other copy is placed in the card holder for that machine. As workmen change their jobs, the lots are given out in succession in the above way.

If the date of delivery of a final lot of material be changed a new date is set on the calendar rule, and all job cards are drawn and re-dated, and are again re-distributed strictly in the order of their dates. This may put them ahead or behind their old schedule positions.

When a workman completes his job he turns in his job card, which is then time-stamped. He is given at once a new job on his machine. The old job card is then sent through to the route sheet and ledgers for record and into the payrolls and costs for the labor determination.

At the same time the duplicate of the old job card is delivered to the inspector, and after inspection to the moveman, by which authorization he moves material to the next operation.

When the job passes through final inspection, it is received in the stock room on the last move ticket and delivered to the assigned location. This last move

ticket then goes through to the records and costs, showing the lot to be closed.

Assemblies are treated exactly the same as parts, except that a "group issue" is used instead of a "single stores issue." The "group issue" may call for purchased finished materials, or for produced materials, and one will be written for each stock room in case the specification calls for it.

The principal feature in this particular control, which differs from anything previously done, is the introduction of standard times for the production of standard lots, and the output determined by the frequency with which the lots are started.

The dating of the job cards from the standard times on the route sheets is easily accomplished, and the responsible authorities are required only to set the date of delivery, after which the route file clerk can set the dates for each operation.

If at 4 o'clock on any day any job on any operation is not on the machine, as called for, a "Lot Urgent" tag is attached, and from that time on the job is worked unceasingly night and day. (This, however, will be described in detail under "Enterprise No. 3.")

As in Enterprise No. 1, the capabilities of different men have been considered and recorded. After each operation on the route sheet is marked the work characteristic letter as *A*, *B* or *C*. Machine symbols are also marked with the same designations for machine conditions. Workmen are interviewed and an agreement is reached for rating men according to ability as *A*, *B* or *C*. With this plan in operation *A* work is automatically despatched to an *A* machine, at which is provided an *A* operator. Except in cases of lack of work

or of heavy peaks this arrangement is rarely broken. Occasionally an *A* man may be operating on a *B* machine on *C* work, etc. Such combinations, however, can only be obtained by request of the despatch clerk upon the shop's supervisor.

Under this plan is obtained a high degree of routing and of despatching, but with the requirement of individual scheduling. That is, each lot of each part must be scheduled independently. This is relatively simple when standard times have been established upon which dates can be readily placed. To re-schedule a part on all operations, the chief schedule clerk is required to set a date of completion on the lot only, all other dates previous to that being set by the calendar rule. If, when dating, any operation is due before the current date, a "Lot Urgent" tag is applied. When this appears, the shop's supervisor is instructed to provide extra facilities for carrying out such work.

The allowance time which has been previously mentioned is very important in the smooth operating of the shop, and it is determined and adjusted until the "Lot Urgent" tags do not become too great for economical working. This allowance time is the time from the finish of one operation on a part to the beginning of the next. It is found by first studying the average condition existing in the shop at the time of its application.

Records are kept of the time when material is started into the shop and the time that it is received in the finished material stock room. The number of operations on a part, that is, the number of moves between machines is used as a divisor for this time. The result is the allowance time per operation. While this obviously will not be constant at first, there is a prob-

ability which must be recognized, that it will require this time on an average. Any longer than such time will cause sluggishness of the movement of work and unnecessary work in process investment account. Any shorter time than this average will be obtained only by intensive supervision. It is well worth while to bring the average allowance time to as limited an amount as is consistent without an undue quantity of "Lot Urgent" tags.

In the writer's experience it has been found in ordinary machine-shop practice, that one current day in addition to the running time of each operation is about the minimum which can be operated, for very good running of a production shop. In the job shop, such as described in Enterprise No. 1, in previous paragraphs, where rapid delivery of orders is needed, this may be worked as low as one-half day. If the allowance is less than one day, then the scheduling of orders must be to the hour, as is done in Enterprise No. 1. If not by the hour, then the allowance time must at least equal one day.

It should be understood that the lot size means that quantity which will move from one operation to another, and at each operation each piece shall be worked upon on that operation before the lot is moved to the next. It does not consider the issuing of a large order and then partial movements thereto, which are not supervised. If any lots are to be broken, it should be done only by special permission of the Production Manager or by someone delegated by him, who will allow no such permission to be extended until after careful consideration of all reasons therefor.

In this enterprise and the one previously mentioned, each order on each part has its individual treatment

for schedule. In Enterprise No. 3 this condition will change, and a schedule for one of the main parts will be so arranged as to become automatically a schedule for each part and each actively included in the major part.

ENTERPRISE NO. 3—PLANT WITH UNIFORM MANUFACTURE

The typical case cited is the manufacture of an automobile, in which there is practically no intermixing of a variety of models, which can be manufactured to a pre-determined schedule. A consideration of this problem will indicate that there is but one article to sell, that is the finished automobile. This cannot be accomplished unless it be accurately co-ordinated, so that the exact quantity of parts come at the correct time, to go in the subsequent assemblies. Any long delay of one part would tie up all industrial activity and restrict all income from salable product.

The principal activity should thus seem to be concentrated upon the co-ordination of all factors which enter into the production of parts and subsequent assemblies in proper chronological order. The product must be thoroughly analyzed and a diagram made showing the path of flow of each of the parts through sub-assemblies and into final assembly. If such a diagram is laid out, showing not only the parts, but each of the activities upon each part, and are arranged to some scale, which will shop the time at which each operation must be done with relation to any other, we have the ground plan for a very simple method of scheduling and of intensive supervision.

To erect such a diagram, the exact producing time for each operation on each part must be known; the allowance time between operations must be known;

the length of time for materials to remain in the Raw Stock Room and in the Finished Stock Room must be standardized; the Purchasing Agent must agree to a standard time, in which to buy, bargain and deliver the different classes of material into the Stock Room after date of requisition therefor. If patterns, dies and tools must be provided for, they should be shown on this diagram in the proper place.

The typical part would then show the following items on the diagram:

1. Specification due from Designing Department
2. Order for pattern or die, if required
3. Pattern or die due, finished
4. Requisition for material
5. Tools ordered
6. Tools finished
7. Material due in stores
8. Material due on first machine or station

9, 10, 11, etc., materials due on subsequent machines and last, material due in Worked Materials or Finished Stock.

Since a variety of parts may be required for one assembly, and the assembly is to be started only when all the parts are available, that is, unit assembly considered, it will be obvious that the elements mentioned above will occur in different time positions for different parts, so that they may all be ready to issue at one time. If this assembly, just mentioned, is one part only of a larger assembly, then the same process will be repeated through to the final assembly of the finished product.

With standard lots established, the producing time per lot on each operation will be constant, and with a

constant allowance time, standard stores and purchasing times, all parts will in general follow closely the same total time from date of first requisition to finished product. If the lot size of some parts will provide for the issue of a number of lots of the assembly into which it goes, the standard lots will be issued less frequently than of some other parts, which satisfy but one or at least a very few lots of the assembly in which they go, that is, the lot sizes of parts may be established on individual economic determination.

The quantity produced will depend upon the frequency with which the lots are started through the different stations in the process of making. If the quantity record at each station is made to read in terms of the number of cars, which will be satisfied by the quantity, with the amount so produced, a schedule can be planned for the *finished product* itself and applied successively over each activity on each part, thus eliminating any need for any other individual scheduling for each part.

Such a diagram as has been mentioned will reduce in its simplest form (and even this is very elaborate) to what has been called a Control Board. These Boards, which have been used by the writer for this purpose, consist of large frames, seven feet high and ten feet long. On the face of each frame are strips, each independent of the other, but supported on wire cables, very much the same as designed for roller doors or roll-top desks. Strips may be added to or taken from this board without difficulty, and as combinations of parts and assemblies change, new ones can be added or the old ones readily removed.

Beginning at the right-hand edge of each strip, consid-

ered as the zero point, each ½ inch to the left is scaled as a working day. Since the boards are ten feet long, this provides for two hundred and forty working days. On the right hand of the zero point appears but one record place, and that is the finished car. To the left and at the proper place, each activity on each part is then recorded. The space for this erection is a steel cage, ½-inch square, in the bottom of which is a marker showing the machine symbol. The operation name of each part, numbers pertaining to lot size and number per car are on a marker at the right hand end of the finished part. That is, if a steering device of a standard lot size of 50 is to be finished and issued to the chassis assembly 20 days before the car can be shipped, the Finished Stock cage for the steering device will be 10 inches, or 20 one-half-inch working days, to the left of the zero or car finish point. Each operation performed on the steering device will have its individual cage at the proper time distance to the left of the Finished Stock cage.

The following details of the exact order of procedure in the use of this type of complex control, while intensive in detail, are the least that will provide useful description. The desire in any intensive management plan, which will eventually be the only one worth while, should be to detail every possible activity to its least form. There is a tendency to feel that this causes a great amount of detail, but it should be recalled that if such detail actually exists somewhere in processes of the manufacturing effort, it is worth while concentrating it into physical demonstration at one location.

To take advantage of the new form of Manufacturing Control, our work plan is as follows:

THE ENGINEERING DEPARTMENT'S DUTIES

Design.
Draft.
Check.
Trace.
Blue print.

Supervise and make alterations on parts drawings and assembly drawings. On part drawings they will show details to include:

Drawing number or symbol, or both.
Form.
Sizes with limits and tolerances.
Character of materials by number corresponding to specification.
Heat treatment or other processes.
Location of parts in groups and models with quantity required in each. They will also show if the part is to perform a new function or is to displace at once, or supersede, a part then in current production.

Assembly drawings will show:

Drawing number or symbol, or both.
Arrangement, location, drawing number, or symbol, and quantity of each part in the assembly.
Miscellaneous classified parts, to be shown by symbols as recorded in the Stores Classification.
Heat treatment or other processes.
Location in other assemblies or models.
Quantity per other assembly and model.

ENGINEERING INSPECTION DUTIES

Inspect and report on all receipts of purchased materials and parts, to agree with Purchase Order and Specifications.

On parts in process inspect for:

Dimension.

Result of heat treatment or processes.

Defects in material or form.

Certify to number perfect or imperfect under the above.

Record findings on Job Inspector's Coupon.

Inspect and test assemblies and finished product.

ROUTING SECTION'S DUTIES AND INSTRUCTIONS

Check engineers' paper drawings for tool construction, manufacturing processes and suggest grouping of parts in assemblies. Any part on assembly drawing must be specific, conform to group, dimensions, etc., as planned, and show all parts on actual record, but no others.

Receive from engineers, blue prints for parts for assemblies on which are shown:

Mark, name or symbol of assembly into which the parts go, and the date at which the first car with the part is to be finished.

Date and send prints to Control Board.

Receive prints from Control Board and date receipt.

Indicate on the parts print:

Symbol of part, if not on the drawing.

The total producing time and number of operations for standard lot.

The work days that the part must first leave Worked Material Stores before the finished car. (A part must always be controlled in the first group, which leaves Worked Materials Stores.)

Specify tools by name, or number, or other drawing used on. Specify work days required to produce.

Specify patterns as new or as used on other drawings. Specify required work days to produce.

Specify lead proofs or samples for approval.

Specify size and form, but lot quantity only of material.

Specify number of pieces in lot.

Determine lot sizes (considering size of assembly into which part goes, bulk of part and total producing time on part).

To determine lot sizes: This important decision must receive most careful attention, since many elements enter into it. Among the most important are:

Number of pieces required for first assembly into which they go.
Lot size of assembly.
Bulk of piece.
Producing time per piece.
Time required to secure material.
Preparation time per lot.
Material value per piece.
Perishable nature of material.
Number of pieces required for one piece of finished product.
Time that piece enters the product before finished product.
Permanency of design.
Probable loss by scrap or diversion (diversion affected by number of assemblies, which finish in sequence).
Number of operations to be performed.
Long time processes (or lot times).
Number of lots required.
Machine burdens (whether continuous or intermittent).

The expression for actual determination of minimum size of lot will be obtained from the Production Manager.

Lot sizes for parts which have long purchase time or go into early assemblies will in general be smaller than under other conditions.

Date and send blue prints to Control Board.

Blue prints must specify the schedule tape by which each part is to be controlled. We have four tapes for Series 8: one for parts common to all models; one for parts used only on Touring; one for parts used only on Runabout, Coupé or Berlin and one for parts used only on Sedans. For any combinations of models other than these, specify such parts for control by the next higher tape; *i.e.*, a part used on Touring and Runabout will be controlled by the all models tape. For such of these parts as are so expensive or bulky that we do not want to manufacture them at too high a rate, use the route sheet method of control.

Specify and add to assembly drawings:

Symbol of assembly, if not on the drawing.

The total producing time and number of operations for standard lot. Allow for single moves or gang of men on same lot.

The work days that the assembly must leave Worked Materials Stores before the finished car.

The tools or other special equipment.

The number of assemblies in lot.

Date and send print to Control Board.

Receive part or assembly from Control Board and date receipt.

Prepare operation sheet.

Send operation sheet to Control Board for erecting operation cages.

Send all new master group issues to the Control Boards for the purpose of checking, to see that we have a strip on the board for each manufactured part. They must also be sent over when any change is made on master.

Prepare a single copy of route sheet and send to vault for emergency use. (Do not draw this route sheet except for emergency use.)

Prepare inspection cards, tool lists, three-copy single stores issue and three-copy group issues for assemblies and send stores group issue to board for location of requisition marker and cage.

Prepare three-copy Job card, Inspector's coupon and Move ticket and Foremen's coupon for each operation (see Figs. 22, 23 and 24).

Maintain a complete stock of all such filled forms and dispose of all which become obsolete.

Prepare pattern order, tool order, lead proof or sample order (if required) and send to Control Board.

Send notice of closed tool orders and pattern orders.

Prepare analysis and standard time sheets for all possible operations.

Order prints from engineers, receive and supply to shops, supervise, account for and return all obsolete prints to the Engineering Department. (If any prints are retained after becoming obsolete, secure such release from Engineering Department, who will mark the print "Obsolete" and date of such action.)

Design tools and equipment.

Specify and order perishable tools and supplies.

Superintend tool grinding and Tool Repair Shop.

Despatch tools.

Inspect and store tools.

Select and requisition machinery, alter, locate and keep in repair.

Prepare machine analysis diagram.

Maintain machine time burden record.

Maintain belt orders.

Maintain local power transmission.

Specify all routing for special or irregular job orders, including returns for repairs.

Prepare route sheets, job cards, tags, store issues, etc., for special job orders.

Obtain schedule from Manager, showing:

Models.

Types.

Special equipment.

Quantities per month.

Re-arrange Managers' schedule and secure a uniform producing schedule.

RETURNED FORM A-1077-S ISSUED		DRAWING NO.	LOT NO.
		21021+	

MAN'S NAME		MAN'S NO. D M
PIECE SYMBOL	OPER. NO.	OPERATION NAME
E25AY1M	2	ROUGH & FIN. BORE

CYLINDER COMPLETE

ORIGINAL PIECES ISSUED	105 58V						DATE DUE ON MACHINE	NO.	DAY	HOUR
MACHINE FOR THIS OPERATION	C1C11	NO. OF GOOD PCS. A CLAIMED FINISHED ON THIS JOB					B PREM. BASE TIME ALLOW'D			
MACHINE WORK'D ON THIS OPR'N		MACHINE					PREM. LIMIT C=AB TIME			
		TIME	COST	NO.	REL.	COST	TIME TAKEN D			
MACHINE FOR NEXT OPERATION	1TC D6M						TIME SAVED E=C−D			
IF JOB IS NOT FINISHED SCRATCH OUT THIS		F	INSPECTED				PREMIUM F=½E TIME			
IF JOB IS FINISHED SCRATCH OUT THIS		NF					EARNING TIME G=D+F			

ROUTE SHEET	PAY ROLL	MAN'S COST	MACH. COST	MAN'S JOB CARD		MAN'S RATE	EARNINGS
				DAY WORK OR PREMIUM	D / G	×	=

FIG. 22

SAMPLE JOB CARD FORM USED BY THE FRANKLIN MANUFACTURING COMPANY

I HAVE INSPECTED THE FIRST PIECES ON THIS JOB AND FOUND THEM O.K. FORM A-1627 SIGNED BY	DRAWING NO.	LOT NO.
	21021	

MAN'S NAME	MAN'S NO. D M

PIECE SYMBOL	OPER. NO.	OPERATION NAME
E25AY1M	2	ROUGH & FIN. BORE

CYLINDER COMPLETE

							DATE DUE ON MACHINE	MO.	DAY	HOUR
ORIGINAL PIECES ISSUED	105									
MACHINE FOR THIS OPERATION	~~58V~~ C1C11									
MACHINE WORK'D ON THIS OPR'N		MATERIAL	DATA	MEANS	STARTED	FINISHED				
MACHINE FOR NEXT OPERATION	~~1TC~~ D6M									

FIG. 23

SAMPLE INSPECTOR'S COUPON AND MOVE TICKET FORM USED BY THE H. H. FRANKLIN MANUFACTURING COMPANY

RETURNED FORM A-1677-A ISSUED		DRAWING NO.	LOT NO.
		21021	

MAN'S NAME	MAN'S NO. D M

PIECE SYMBOL	OPER. NO.	OPERATION NAME
E25AY1M	2	ROUGH & FIN. BORE

CYLINDER COMPLETE

ORIGINAL PIECES ISSUED	105	REASONS	DATE DUE ON MACHINE	MO.	DAY	HOUR
MACHINE FOR THIS OPERATION	58V C1C11	PIECES SPOILED		WT.	MATERIAL	
MACHINE WORK'D ON THIS OPR'N		PIECES DEFECT'VE				
MACHINE FOR NEXT OPERATION	1TC D6M	PIECES FOR REPAIR				
MARK OFF MACHINES NOT WORKED ON		GOOD FOR - W'RD'D		MOVED TO	MO.	DAY	HOUR	REC'D BY
ROUTE SHEET	MOVED BY 1ST							
	INSPECTED BY							
	MOVED BY 2ND							

FIG. 24

FOREMAN'S COUPON FORM USED BY THE H. H. FRANKLIN MANUFACTURING COMPANY

Prepare master sheet for Control Board schedule tape as follows:

Lay off on one-half inch (½ in.) co-ordinate paper as many one-half inch (½ in.) spaces as there are work days in which to assemble the uniform schedule. At the right end of this sheet, the beginning of the producing period is the zero point.

Erect at this point a vertical line of any scale to a value, which represents the weekly production of all models at the beginning of the period.

At the extreme left of this sheet, the end of the producing period, erect another vertical line with the same scale as the first and to a value, which represents the weekly production of all models at the end of the period. If these lines are of different length, that is, if the rate is different, connect the tops of the vertical lines by a curved line as specified by the Production Manager. If the value of the two vertical lines is the same, *i.e.*, if rate of production does not change, the base line can be used on which to lay off the schedule.

The length of the line connecting the tops of the vertical lines will represent the total number of cars to be produced over the period. Beginning at the right end of this line, lay off to the left distances of 500 cars each and mark the line. Drop a vertical line to the base line from each of these points. This will divide the base line into several divisions of 500 cars each, but if the line is much curved, the distances will be uneven.

Reduce each space on base line so provided ten per cent. (10%) and mark back on the base line to the right of each vertical line to show this distance. The remaining ninety per cent. (90%) of the space

will then be divided uniformly into (20) equal parts.

Then if a reducing factor of 1/5 is used: the number over the starting point of the first division to the right will be zero. Over the next one 5, the next 10, the next 5.....95, which will be over next to last mark. 100 will be over the first mark of the next division, and then 105, 110, 115..... 195. This will be continued for each section. The percentage reduction space causes an increase in the rate of the production before it, so that any lack of accomplishment in a period can be made up in the allowance time preceding the beginning of the succeeding period.

It will be evident from inspection of this diagram that each unit number on the tape represents but one-fifth of the schedule, and that any number of cars indicated by the tape can be found by multiplying by five the denominator of the "Quantity Block."

If the quantity is small over a long period, or if the schedule for some parts differs from others, a division of 50, 100, 200, etc., may be used in place of 500. As stated above, the number of cars is then to be found by multiplying the number on the tape by ½, 1, 2, etc., and this number used as the denominator of the quantity block ("Q" block). Such parts should be grouped on a board under a common tape, which has lines designed especially for that board. This can be illustrated as follows: If schedule contains Touring, Runabout and Sedans for first half of period, all common parts will be grouped on as many boards as required, uncommon Touring on another, Runabout on another and Sedan on another. On "common" board tapes use a division of 500 cars—"*Q*" block de-

nominator = 5. On Touring only, a division of 300 cars —"*Q*" block denominator = 3. On Runabout, a division of 100 cars—"*Q*" block denominator = 1 and on Sedan, a division of 50 cars—"*Q*" block denominator = ½. As the relative schedules change, the period time on which the tape is laid out must be changed and new tapes made to cover period. The quantities in the divisions, or "*Q*" block denominator, need not be changed unless the quantities are greatly changed. ("*Q*" block denominators may be modified by percentage factors for car, group, division, section or sub-section so as to provide for standard losses or diversions. These factors will always be specified by the Production Manager. If these factors are used, schedules will complete for different parts and assemblies at different tape numbers, and schedule cages must be maintained at the requisition, "*R*," block for each part and assembly. In this cage will be posted the quantity (in "board units") of parts yet to be ordered, as authorized by the total schedule of the part. As losses and diversions are corrected to "board units" and quantities in operation cages are reduced, the quantity is added to the schedule cage. When new orders are written, the quantity in "board units" of the order will be removed from the "schedule" cage. When the quantity in the schedule cage becomes zero, a new schedule must be obtained.

After the paper layout for the tape is completed, this will be traced on one and one-quarter inch (1¼ in.) thin satin ribbon, the numbers being stamped with a rubber stamp and printers' ink, squeezed on a glass plate. The one-inch day tape and the one-inch calendar tape will be prepared at this time or at such a time as may be convenient, but never later than the schedule tape.

The space interval for the work day tape and the

calendar tape will always be the interval of the layout sheet for the schedule tape, *i.e.*, one-half inch scale.

THE ERECTING CLERK'S DUTIES AND INSTRUCTIONS

Print schedule tapes and place them on the reels.

Receive blue prints from Route Division and write marker for print, showing name and drawing number and symbol, if on the drawing.

Erect a black strip for a part and white strip for an assembly on the Control Board, located in groups as specified on the print and place a marker at extreme right-hand end.

Erect (when necessary) a strip on Control Board for single stores issue, routed into the part preceding at a particular operation, to include a requisition cage, due in stores cage and an issue cage. For completes made of two kinds of raw material, issued at different times, two strips are to be used, one to have only a stores cage for the material last issued and a marker to indicate the time and location to which it is to be issued.

Sign, date, and return print to Route Division.

Receive print subsequently.

Write additional markers as indicated by the print to include:

Quantity block.
Worked material block.
Inspector's block.
Stores block.
Requisition block (Post tape number corresponding to first finished car into which part goes).
Schedule block.
Pattern or lead proof block. (Mark with tape

number as mentioned.) Lead proof block to be erected 30 days after requisition block.

Tool block (Mark with tape number).

Marker to show that part is added or displaces or supersedes other part. (Do not remove a superseded part or assembly strip until Order Clerk releases it.)

Add these to the strip as indicated by the parts print and Purchasing Agent's standard "Purchased Time List."

Sign, date and return print to Route Division.

Receive operation sheet.

Write marker to show number of operation and symbol of machine or department.

Erect cages according to the operation sheet and make any re-arrangements of the original location of strips or markers.

For each assembly, check to see that a part strip is in place for each part, as shown in assembly worked material master group issue.

Sign, date and return operation sheet to Route Division.

Maintain the board in first-class repair, and under no circumstances allow any markers, type faces or flags to lie on floor under boards.

Demand written instructions for any changes, if deemed necessary.

Maintain a supply of all materials, including ribbons and reel cords.

Provide for and assist with photographic mechanism.

If any changes of operations or assemblies cause changes in the assembling time, the *part strips* of such assembly will be moved to correspond, and the Order Clerk will be at once notified in writing of such moves.

ORDER CLERK'S DUTIES

Adjust schedule tape to agree to schedule time as follows:

Learn from the Production Manager the date that cars at any point on the schedule tape are due to Sales Department and set the calendar tape so that this date is at the extreme right-hand end of the Control Board.

He will then set this special number on the schedule tape over the current date on the calendar tape.

Other movements of the tape will agree to the tape on master board in the Production Manager's office, but in general the tape will move one-half inch to the right for each work day.

At each move of the schedule tape, the Order Clerk will inspect each cage on the Control Board and note its standing with respect to the number on the schedule tape immediately above it.

He will date and deliver to the Route File Clerk:

Single stores issues.
Group issues.
Tags.
Job cards.

Instructions for dating paper: Since losses by diverting or scrap changes the schedule of parts, and in so doing changes the quantity in the stations, all datings should be conducted as follows: Determine the board unit for the preceding lot number (in general this will be the last number on the board, but in case of re-dating will not), find this number on the tape and place the current date of date tape, which is immediately adjacent, to the corresponding cage. If board

strips are moved, due to changes in time of operations, or if cages are moved due to the same reason, then all paper affected should be recalled for new dates.

When each stores issue is sent for apportionment, he will place green marker in requisition cage.

When a call is made upon Route File Clerk for requisition and job cards for a part, he will place a green marker in first operation cage.

When requisition is dated and sent to Route File Clerk, the Order Clerk will transfer green marker from first operation cage to storage cage. This will be removed by Posting Clerk when material is issued from Stores.

If any operation on a complete depends on material or a worked material part, stamp last operation card of the part to show drawing number of complete waiting for it and on the operation card to follow for the complete stamp ("do not post until part No. .... is received at Job Station").

Single stores issues, tags, group issues, or job cards will be delivered to Route File Clerk six days preceding exact schedule of the cage.

Worked material issue will be apportioned and delivered two days before date due.

For work done on standing orders, such as heat treating, nickel plating and black enameling, job cards will be written for each operation and will be used for posting the Control Boards and moving lots. When the Despatch Clerk receives notice that any of these operations on any lot is completed, such job card will be marked "*F*" and sent to the Control Boards for posting

and the move coupon to the move man. These cards will not show time, and are not to be sent to the Cost Department.

He will see that produced quantities do not get too far ahead of schedule, and from time to time will confer with the Production Manager for guidance.

If any number on the board is overrun by the corresponding number on the schedule tape, he will obtain a red tag from Route File Clerk and place red marker in cage. He will place any such marker on notice from Despatch Clerk.

He will watch the quantity under "Diverted" and "Scrapped," and when large will order the board unit cage standings reduced by the amount. If quantity lost or diverted is very large, all papers on all lots in process should be re-dated to advance them. This is also true when a change of time of assembly causes notice of shift of parts by Erecting Clerk.

He will receive from Stores, Form A 1138, report when any material is scrapped for Stores or is used on any other order other than those to which it has been apportioned. When this depletion amounts to a fraction of a lot size, the stores cage on the Control Boards must be reduced a full lot size.

When a part or assembly becomes obsolete, he will record the number of pieces so obsoleted on Form (—) and turn it over to the Route File Clerk for notification to Service Department and for file. If an assembly becomes obsolete and its strip is to be removed from the board, and pieces of assembly are standing in Worked Materials they will be treated as if diverted, and the diverted cage of each old part, which continues in current production, will be posted with the number of pieces so diverted. If the assembly is after-

ward scrapped and the pieces re-claimed, the number placed in stock will be removed from the diverted cage and added to the Worked Material cage for each part. Such postings will be made by the Posting Clerk from written notices of the Order Clerk.

He will check Worked Material tags to cages and send to Route File Clerk for correction or file.

His prime responsibility will be to start all operations, including requisitions, etc., on schedule time.

He is to notify in writing, by standard forms, or otherwise, those persons who are responsible for the particular item considered.

He should feel the responsibility of keeping the shop attainment up to schedule.

ROUTE FILE CLERK'S DUTIES

He will receive all paper from the Order Clerk and distribute it to the proper place.

He will receive all paper from the despatch racks and distribute it to the proper place at the boards.

He will post in a ledger all lots started or finished, by drawing number, lot number and quantity. Also show special apportionments as sundry, etc., and any notes about particular lots that are deemed necessary.

He will supervise Despatch Clerks and Posting Clerks.

Immediately on receipt from Order Clerk, he will send stores issues to Balance Stores Ledgers for apportionment.

He will receive apportioned paper and, after posting, will file.

He will send copy of stores issues to Cost Department, and on receipt will file.

He will post all receipts of materials against apportioned paper and pass receiving ticket to the Posting Clerks to post on Control Boards in stores cages.

He will apportion delayed parts in Worked Material group issues upon notice of receipt from Posting Clerk.

He will maintain route sheets for job orders and prepare move tickets for all such jobs.

He will secure job cards for all jobs from route department file.

The paper used by the Route File Clerk will be handled as follows: The stores issue will be in three copies, and will combine material and move tickets within the same form.

When the paper has been dated and a green marker placed by the Order Clerk and turned over to the Route File Clerk, he will send the face copy to the stores ledger for apportionment, allowing them twelve hours in which to return it.

The face copy will then be delivered to the Posting Clerk for posting "Stores Cage" and to indicate removal of green requisition marker. The Posting Clerk will be required to return this paper within twelve hours to the Route File Clerk for file.

In case the stores apportionment does not show full quantity of stock on hand, such receipt of the material will be posted by the Route File Clerk to the face copy from the Stores Receiving Ticket and be passed to the Posting Clerk for "Stores Cage."

The Stores Receiving Ticket in all cases will be marked by Stores Clerk with orders waiting for material, and will show the drawing number, or symbol, lot number and quantity, which are covered by the receipt.

At the time of sending face copy to Stores Ledgers,

the second copy will be sent to the Cost Department as a notification for them to open orders. The Cost Department will return this paper within twelve hours for file to the Route File Clerk.

The third copy will be placed in tickler under date of stores due, and will be used to start lot.

One day before date material is to be issued from the stock room, the three copies of the group issue will be sent to the stock room. If the material cannot start, a red tag will be written and filed in tickler against third copy and notice sent to the Order Clerk, who will mark first operation cage under same plan as for job cards.

If a Worked Material group cannot start due to shortage of part or parts, a red marker will be placed in Worked Material cage of parts by Order Clerk, and when parts are received, the Route File Clerk will be notified and the red marker removed.

After delivery and receipt by foreman, the Stores Department will return the face copy of Stores to the Stores Ledgers, Worked Material to Route File Clerk, and both to Cost Department to show the charge out of stores.

They will send the second copy to the Route File Clerk and Posting Clerk, from which will be posted the move to the first machine. If assemblies require both Stores and Worked Material group issues, they will be issued at the same time. Assembly blocks (*R*) will show Stores group or Worked Material group, one or both, as they occur. If there is a group of each, and one is up to the Board, a blue marker is placed in first operation cage, but the quantity is not posted. When the second one reaches the Board, the blue marker is removed and the quantity posted.

The third copy goes to the despatch rack with the goods, or on those floors not having a despatch rack, goes to the foreman and becomes his property.

Jobs up to machines, except the first operation, will be posted from the finished (*F*) job card of the particular lot and previous operation.

The job cards must be returned the same day to Despatch Clerks to arrange for the Cost Department and pay roll.

When a job card passes from one department to another or to Worked Materials, after posting, the cage receiving will be marked with a blue marker, which marker will be removed by Posting Clerk on receipt of the combined Inspector's Coupon and Move Ticket.

Moves into worked materials will be posted in the same way.

Spoiled and defective work will be posted from the Move to Worked Material tickets.

The Move ticket into Worked Materials will, after going to the Board (and if part was short, after apportionment to Worked Material group issue) will be sent to the Cost Department as instructions to close the order. It will be returned by the Cost Department inside of twenty-four hours for permanent file.

Tool and pattern movements will be posted from the tool and pattern order.

If the Order Clerk finds any discrepancies between the stock tags and the Worked Material cages, these will be taken by the Route File Clerk, investigated and any discrepancies existing will be adjusted and marked on the tag from which the Posting Clerks will change the Board.

Any corrections or alterations to the data on the Board will go through the Route File Clerk in writing,

and after approval by him will be posted by the Posting Clerk.

POSTING CLERKS' DUTIES

They will receive their instructions from the Route File Clerk.

They will receive from the Route File Clerk any paper, which is to be posted to the Control Boards. As far as possible this will be taken from baskets attached to the Control Board.

They will sort and classify their paper to the different Control Boards, if this has not been done previously by the Route File Clerk.

They will find the part and operations considered and from the numbers standing at the operation moved from and the operation moved to will calculate the new quantities with a Munroe Calculator and post the cages.

They should calculate to a decimal of a unit and should watch to see that if the moves work out to a decimal that they are not posted all in one way.

All quantities except Worked Material diverted and scrapped will be divided by the denominator on "*Q*" block (these exceptions will be posted to show the exact quantity).

Whenever an out move is made from Worked Material by group issue or single issue, whether current production or diversion, the quantity on hand in Worked Material cage will be reduced by the amount taken out.

When any assembly is diverted (also see obsoleted under Order Clerk) the "Diverted" cage for such assembly will be posted with the number of such pieces.

When such assemblies as Diverted are to be ad-

justed, reduce Diverted to Board Units and subtract all assembly Board Unit cages except Stores. At the same time post in Diverted cage of each part contained in the assembly the number of pieces so diverted.

In the Stores cage will be posted in quantities of the Board Unit (the Board Unit to mean any quantity divided by the denominator of "*Q*" block) such quantity as is shown to be covered by Apportionment. The Stores cage shows what material is in stock that has been apportioned against the particular part.

When correcting Worked Material tags to Boards, if tag shows *less* than quantity in Worked Material cage, reduce pieces in Worked Material cages to agree to tag, and post in "Diverted" cage the amount of difference. If tag shows *more,* add to Worked Material cage and reduce any pieces in Diverted or Scrapped cages a like amount; if no quantity is shown in "Diverted" or Scrap cages, divide by "*Q*" denominator and add to all previous cages except "Stores" cage and subtract from Schedule cage.

The Posting Clerks will be held accountable for the accuracy of all records on the Boards, and no one will be allowed to move or change any such records without a complete understanding or arrangement with the Posting Clerk.

The Posting Clerks will assist as far as possible to bring to attention any general errors existing in the Board or any discrepancies that they may notice between the tape and any corresponding cages.

Whenever posting to a cage that has a red marker when the paper is marked with a red cross, such red marker must be removed. In all other cases, the red marker will be replaced. If red marker stands in Worked Material cage, when a full lot of parts move

in, the Route File Clerk will be at once notified by Move ticket and the red marker removed.

Green marker will be removed when apportioned stores paper is posted.

Blue marker will be added to receiving cage when (*F*) card shows changed department and will be removed when Move ticket is received.

Any work done in the factory that is not conventionally posted on the Control Boards must be carried out by route sheets.

DESPATCH CLERKS' DUTIES

When job cards are started by the Order Clerk they will be posted in the despatch boxes.

When the material is received at the machine, in the second compartment of the machine box will be placed the job card and inspector's coupon, while the foreman's coupon will be sent to him. All other jobs on that part for that lot will be posted at the proper machines in the third compartment.

On giving out job cards, the workman's name, clock number and the machine on which he actually is to do work will be marked.

The card will then be time stamped and handed to the workman or will be put in the workman's attendance racks.

The attendance racks will be the responsibility of the Despatch Clerks.

They will be filled with job cards before the closing at night.

They will be unlocked by the watchman in the morning and will be locked by the Despatch Clerks at 7 o'clock, unlocked by them at 12 o'clock, locked at 1 o'clock and unlocked at 5 o'clock.

All job cards will be removed that remain after time of locking.

Workmen not in on time will be obliged to report to the Despatch Office for a job.

They will be required to sign a late or absent card, which will account for the time so lost.

The job cards in machine racks will be arranged in the second compartment in the order of their date and given out in this order; in the third compartment, in order of their drawing number; and they must be maintained accurately this way.

No exceptions to this will be allowed even temporarily without the Production Manager's authority.

If exception must be taken, consult at once with the Route File Clerk or mark with a slip of paper showing that such irregularity is known to the Despatch Clerks.

All (*F*) job cards must be delivered to the Route File Clerk for Posting Clerks and when returned must, with all other unfinished cards, be accounted for and arranged for Cost Department.

When an operation on any lot cannot be put on machine on date, put a red tag on that lot. When the lot gets up to schedule date again, remove the tag. If a tag placed is the only tag on the operation, report at once in writing the placing of that tag to the Control Board. This report to show drawing and operation number. If, however, another lot of the same part on that operation already bears a tag and has been reported to the Board, do not report the tagging of any later lot; in other words, the report of red tags sent to the Board is to be a report of operations tagged rather than lots tagged.

When a tag is removed from a lot, if other tags still

remain on that operation, simply destroy the tag removed, but if the tag removed is the last tag on that operation, mark the (*F*) job card with red cross.

The Despatch Clerks must give very quick and prompt service and accord every possible courtesy to the workmen. If the workmen claim that the job cannot be handled, refer the workmen at once to the foreman.

They will post any route sheets for jobs, which are operated on special orders, if in the discretion of the Route File Clerk it is more economical for them to do so than for the Route File Clerk to do it.

They will receive cards from the workmen and time stamp them.

As one job is finished on one machine, they will move up the next job in the next machine rack from the information on the card.

They will time stamp the inspector's coupon when the job is started and when it is finished.

They will issue the coupon as a Move between the machines or departments.

They will receive these tickets after moving and deliver to the Route File Clerk.

They will make up the job cards and account for all hours of attendance.

They will time and account for all late and absence slips.

INSPECTOR OF RECORDS' DUTIES

The duties of the Inspector will be to verify that all of the clerical work required in the above is carried out with exactness and he will be looked to for final responsibility as to the general accuracy of the conduct of the above work.

He will record his findings, place the responsibility and report to the Production Manager for all errors found. He will bring such errors at once to the attention of the responsible person so that they may be corrected. All reports must be in writing.

To check standings proceed as follows:

Multiply any value in "Board Units" by denominator of "*Q*" block. This will give pieces. Add or subtract any other pieces desired and compare with other values. EXAMPLE: Check part into Worked Material with outgoing assembly. (Note: Other assemblies may take this part.)

Multiply first figures in assembly cage by denominator of "*Q*" block for this assembly. Multiply this quantity by the number of the part (which is being compared) per assembly. Add pieces in Worked Material and pieces Scrapped and Diverted for the part to this quantity. Then multiply figure in D81M cage of part by the denominator on "*Q*" block for the part. This quantity should equal the first quantity.

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